FOOD AND NUTRITION

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THE PHYSIOLOGICAL BASES OF HUMAN NUTRITION

BY

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PREFACE

In presenting a brief survey of our present knowledge of the physiology of Food and Nutrition and of the means whereby this country met the problems of feeding the nation during six years of war, I have had in mind medical practitioners, medical students and those of the general public who are particularly interested in the part food plays in promoting and maintaining the welfare of the individual as well as that of the nation. The recent ideas of the General Medical Council concerning the training of candidates for the Diploma in Public Health have also been borne in mind. The suggestion that they should be given courses in the Physiology and Biochemistry of Food and Nutrition means that they must have a knowledge of the physiological bases of nutrition, dietary planning and the social and economic aspects of food.

A strong belief in the value of historical knowledge in understanding the development and significance of modern scientific investigation has led me to introductions of certain parts of the subject which may be considered all too brief. For those who feel disposed to criticise such brevity references are given. An equally strong belief in experimental evidence may, in the eyes of the general reader, appear to have led me into unnecessary by-paths, but the evidence of experiment is all important and so great is the bulk of it in nutrition to-day, that selection presents an ever growing difficulty. During six years of war the experimental field of nutrition has been extended in many interesting directions. To some of the work reference has been made, but much still remains to be published. The body of evidence concerning nutrients, food processing, and nutrition in relation to human well-being continues to grow so rapidly that the time is ripe for a British Journal of Nutrition.

War has emphasised with harshness and urgency what political reform has envisaged for many years, namely, the need of a greater production and better distribution of food in the interests of the nutritional status of our people. The hope of peace demands that, in the international sphere, this principle be not lost sight of. To this end, and with commendable vision, the United Nations Conference on Food and Agriculture convened at Hot Springs, U.S.A., in May 1943, resolved upon the formation of a World Food and Agriculture Organization. This Organisation was established on October 16, 1945, with Sir John B. Orr, F.R.S., as its Director-General, and with its creation the first plank to bridge the gulf between War and Peace had been fashioned. Naturally it is not the only plank required to bridge this great gulf, but it is, at present, the only one apparently sufficiently well prepared to bear the weight of responsibility it is destined to carry. It may not be too much to say that the hope of World Peace depends upon it.

In gathering together scientific and medical data one soon becomes aware of one's indebtedness to others. I should like to express my thanks to those who by reprints or personal letters have kept me informed as to the latest developments in their respective spheres of research and to those who, in this country and abroad, have so willingly granted me permission to use their illustrations.

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CHAPTER I

INTRODUCTORY

THE EVOLUTION OF HUMAN DIETARIES

THE evolution of the dietaries of man has had a distinct and characteristic influence upon the development of man himself. In the Simian Period, the Primates, because of their prehensile powers, fed chiefly on fruit, beans, roots and to some extent on birds and small mammals. When, in the course of time, man began to employ special devices in hunting and fishing, he became less dependent upon vegetable food and more and more dependent upon animal food. In doing so, he lost, to a great extent, his power of digesting what would now be regarded as most indigestible and unpalatable forms of vegetable food. In those early prehistoric days, a good nutrition must have waited upon good mastication, for in prehistoric man an excellent masseteric musculature and salivary mechanism were associated with a dental array which may have been as alarming as it undoubtedly was efficient. Certainly in those days much of salivary digestion was carried on in the mouth and not, as to-day, relegated almost entirely to the small intestine. A marked step forward in the evolution of dietary habits was taken when man learned to cook. In so doing he increased his food supply, lessened the time required for mastication, increased the amount of vegetable food taken, but lost to a large extent his power of digesting raw foods. There still exist in the world to-day peoples who are representative of this period in the evolutionary history of man. They are the Bushmen of South Africa, the Veddahs of Ceylon, certain American Indians and the Esquimaux. While geographically and ethnologically separated, their mode of eating is proof of their common origin. Before the advent of the use of boiling water in cooking, man used surface fires and underground ovens. In certain parts of the world, for example, in New Zealand, boiling pools afford an excellent means of cooking, but it was not until man created for himself receptacles which would both hold water and resist heat, that he was able to boil water in

order to cook his food. Not only by a remarkable resourcefulness and ingenuity did man select the food which he desired to cook, but he soon learned how to extract starch or sugar from foods rich in these substances. In the pre-agricultural period of man's existence, there appears to have been no knowledge of the art of making beverages, at least not of the art of making alcohol.

In the course of his long prehistoric existence, man had noted the quick passage of the sun, the slower motion of the moon and the long cycle of the great stars. The impression which these heavenly bodies must have made upon his mind, clouded and dominated by superstition and fear, must have been tremendous. In noting the equinoctial position of the sun, sensing the meaning of springtime in the regularly recurring outbursts of new life around him and ultimately realizing the significance of the cycle of the seasons, primitive man awoke to the meaning of springtime and harvest. The first experiments in agriculture had begun. No longer did he rely entirely upon the forests, the lakes, the rivers and the sea for his food, but he began now to assure himself of a regular and known supply of his material needs. Naturally at first, being still a migratory animal, his efforts in agriculture were doubtless spasmodic and limited, but as primitive digging implements of wood and bone gave way to the neolithic tools, the pick, the adze and the axe, a period of more stationary agriculture was introduced. In the migratory period, man had learned how to rear animals, to tend herds and to secure for himself a very valuable mammalian source of food supply. He had throughout the long process of the conquest of the seasons succeeded in securing for himself a mixed animal and vegetable dietary. His fortuitous existence as a primitive Primate had ended and he had entered upon that period of neolithic development which was to be the forerunner of the ancient civilizations of China and Egypt (*ca.* 4000 B.C.).

The Effect of Climate, Racial and Religious Differences upon Dietary Habits.—Throughout the agricultural period, as he continued to develop the cultivation of cereals, cane sugar and fruit, man came to rely less and less upon raw vegetables. As populations increased and tribes wandered further and further into the unknown seeking new areas for cultivation and developing new crafts, greater variations in dietary customs

became manifest. In the tropics a purely vegetarian mode of existence contrasted strongly with the carnivorous instincts of those who had elected to live their lives in the cold and less sunny regions of the arctic and sub-arctic climates. There were, of course, intermediary groups who did not rely entirely upon either fruits and vegetables or on cooked seal, walrus and whale. To climatic variations were added those of race and religion. The racial differences are more difficult to explain. Not only do we find primitive peoples who, like the aborigines of Australia, are very fond of putrid, fatty flesh, be it fish or fowl, or like the natives of Tierra del Fuego who, according to Darwin in his *Voyage of the Beagle*, regard the floating carcase of a putrid whale as a rich feast in store, but on the other hand, we find less primitive peoples, such as the Veddahs of Ceylon, who favour decayed meat with the added luxury of large masses of honey, and in India certain classes to whom putrefying fish is quite acceptable as an article of diet. In the Far East there are the Chinese, a people of ancient culture for whom milk and butter appear to have but little attraction.

In the religious sphere we find the Buddhist, to whom the taking of life is strictly forbidden, and for whom in China and Japan, and in India, the home of Buddhism, the eating of certain fish has become a quite orthodox custom. To-day the traditional attitude of avoidance of pork and alcohol by orthodox Mohammedans is well known. The Levitic Law stands pre-eminent as an example of priestly dictation in the interests of public or tribal health. What was once declared "unclean, an abomination", was strictly avoided, ultimately to become abhorred. Several animals, including the camel and the pig, many birds, fish without scales or fins, are to be found in this priestly category of things forbidden. It would appear that in the long history of the development of dietary habits, there has been a steady tendency in temperate climates to replace vegetable food by a greater dependence upon animal food. It has often been stated, with what truth we are free to surmize, that animal food has played a decisive part in human evolution. Perhaps too much stress has been laid upon this aspect of evolution, but nevertheless it is true that animal protein foods do exert a stimulating effect upon the complex of chemical processes within the body. To secure all the elements of the proteins necessary for body-building, much

more of vegetable than animal protein must be eaten. These animal foods, in conjunction with geographic position and climatic conditions, have a very important ethnological significance. That this is true of man is borne out by the appearance and disappearance of certain races, tribes and communities. Some races are tall, healthy and long-lived; others are puny, disease-ridden and prematurely senile. Heredity does, and always will, play an important part in determining human stature and health; but climate also plays a part, even if a small part, in determining physical and mental characteristics, and it must now be accepted that diet also plays its part, a fact which in the opinion of some outweighs both heredity and climate combined. One of the most interesting reports on the part played by diet in the development of races has been published by the Medical Research Council of Great Britain. It is a study of the physique and health of two African hill tribes in Kenya, by Sir John Orr and Dr. Gilks. One tribe, the Kikuyu, is vegetarian; the other, the Masai, is carnivorous. The Kikuyu tribe is agricultural, and, although the natives possess large herds of goats, they practically never eat meat. Meat is the diet of the old men of the tribe, the others live on cereals, tubers, plantains, legumes and green leaves. Sixty per cent of the diet of the males consists of maize and millet. The Masai, on the other hand, are a pastoral tribe; the staple diet of the young men consists of meat, milk and blood; the older people eat bananas, beans, maize and millet. It is interesting to note the physical characteristics of these two tribes, the one vegetarian, the other meat-eating. At every age the Masai tribes are taller and heavier than the Kikuyu; at the age of twenty-three years there is an average difference of five inches in height. At the same age the Masai women are three inches taller than their vegetarian neighbours. Measurements of physical strength show that the Masai present a marked superiority, the Masai women even being as strong as the Kikuyu men. Interesting are the diseases to which these tribes are prone. Dental caries is not common in either, but it is more prevalent in the Kikuyu children. Anæmia, unknown amongst the Masai children, is prevalent among the Kikuyu children. Bone deformities, as one would expect, are absent from the Masai, but definitely present in the Kikuyu. The resistance to tropical diseases, tuberculosis and pneumonia is greater with the meat-eaters,

but the prevalence of rheumatic troubles, arthritis and constipation is very marked in the Masai, troubles which are not to be found amongst the vegetarian Kikuyu. Before the white man came, the Masai lorded it over their puny neighbours; they were a fearless tribe; to hunt lion with only a spear was a common task of this virile tribe. The moral to be drawn from this comparison is that meat in moderation is an excellent adjunct to milk, green vegetables and cereals.

Such results are not confined to Kenya, but can be obtained throughout India, where various races subsisting on different diets give great opportunity for investigation of the numerous problems associated with nutrition and national health. The diets of Bengalis, Sikhs and Pathans vary in certain respects and comparing their dietaries, relative to their build and mode of life, one can see how diet does play a part in the development of the physical and mental characteristics of people.

The Impact of Social Conditions in Britain on Food and Feeding.—Having looked at the broad lines of development which have led up to distinct racial and tribal differences, we may now consider the progress in dietary advance in this country in its relation to social conditions. In mediæval times a clean-cut distinction existed in almost all respects between the Lord of the Manor and the common people. The crops grown on the manor lands by the common people were wheat, barley, oats, rye and beans. In the south, wheat and rye were the principal crops and these were often from mixed sowing, and from this fact arose the word "maslin" (Latin, *miscere* = to mix) which denoted the finely ground and sieved flour obtained from these crops. In the fourteenth century there is evidence of the cultivation of vegetables and fruits in England. This was a late development compared with what obtained in France and Italy, where by that time gardens were plentiful. In all circumstances, livestock, supporting the animal protein requirements of the people, were kept by landowners.

In the fourteenth and fifteenth centuries the bondage of serfdom slowly disappeared and we find a steady increase in tenant farmers and yeomen. By the system of Tudor enclosures, resulting from the growth of the wool trade, arable land was sacrificed to an astonishing degree to increase grazing, and much economic distress was caused thereby. This was accompanied by a deterioration in the diet of the common people. The

lack of grazing lands led to a decrease in dairy cows, which were the source of the " white meats " as dairy produce was called. This period of depression was probably responsible for a remarkable increase in gardening in which the Dutch were particularly skilful. With the growing of fruits, vegetables and potatoes and the improvement in agriculture which accompanied the increasing stability of the realm under Elizabeth, the diet of the common people living on the land and in the small towns again improved. In the larger towns, however, and particularly amongst the urban populations of large cities like London and York, the quality of the food was very bad and the practice of food adulteration grew to a scandalous extent.

Tudor days saw the first attempt to bring fish from the coastal towns to the large cities. The results were, to say the least, unsavoury. Putrefaction, with its attendant odours, or the odour itself, was regarded as the cause of the frequent outbreaks of plague so notable a feature of the fifteenth and sixteenth centuries. The trade in herrings was considerable —they were cheap, 40 a penny—and herrings with, occasionally, salmon, formed a valuable addition to a diet, not good in the large cities but on the whole very good in coastal and rural areas.

Before the nineteenth century, bread was made from wholemeal flour prepared by stone grinding, the coarse particles of the bran being removed by " bolting " through linen or woollen cloth of various degrees of coarseness. The more finely this flour was sieved the lighter in colour it became until the finest quality was of a pale cream colour. In the Tudor period this flour was called " manchet " and it became the sign of a type of living associated with the Court and later with the families of the rich.

Reference is made not infrequently to the peasant's diet of the fifteenth and sixteenth centuries, emphasis being laid upon its wholesomeness. Wholemeal bread and fruits in season were eaten freely. Vegetables and potatoes did not then bulk largely in his diet and it is for this reason that scurvy was a prevalent disease. If the peasant could secure a goodly supply of " the white meats ", milk, whey, cheese and eggs, then regarded as a low class diet, he had a diet which was far superior to that eaten by many of our working classes to-day.

The formation of the East India Company in 1600 may be regarded as the first official pronouncement that England was to prosecute oversea trade far beyond the limits hitherto covered by such chartered companies as the Turkey Company (1581) and the Russian Company (1566). Throughout the seventeenth century this trade grew apace and in the eighteenth century became the open sesame to the great developments of our commercial and colonial empire. Our navy virtually commanded the seven seas and our merchant ships traded to the four corners of the earth, opening up tremendous possibilities for wealth, and bringing ever new ideas which had their effect on the diet and social customs of the peoples of these islands.

In the realm of our national dietary two changes amongst many were noteworthy—the importation of tea and sugar. Three hundred years ago sugar was unknown as an article of diet. In the days of Marie Antoinette it was an expensive luxury sold at about 4s. or 5s. per lb. At the end of the Napoleonic wars, which had cut Europe off from her source of sugar supplies, France and Germany had established the manufacture of sugar from beet, but English people had insular prejudices concerning beet sugar and were apparently content to pay dearly for cane sugar which for them was rapidly becoming a necessity. The history of sugar is the history of a habit-forming foodstuff. As sugar consumers we run a very close second to the people of the North American continent. From 1836 to 1936 the consumption of sugar rose in this country from approximately 10 to 100 lb. per head per annum. The great increase in the use of sugar has not been without its effect upon our taste for other and better foods. The craving for sugar has led to the use of unbalanced diets, for sugar eaten in excess destroys the appetite for those foods which supply the all-essential proteins, vitamins and mineral salts. From being a rarity sold by the Pepperers, the predecessors of our grocers, sugar has become the cheapest available source of energy.

Another of the striking changes in English dietary habits was the adoption of tea-drinking. Coffee introduced from Turkey and chocolate from the West Indies had become established as beverages in the seventeenth century. Tea from China and the Dutch East Indies was first sold in England at £3 10s. per lb. So quickly did it gain in popularity that it soon became coupled with coffee and chocolate in the

numerous London coffee houses where men from every walk of life congregated. When the East India Company began to bring large consignments of tea from India and China, the price fell until at the end of the seventeenth century it cost approximately 2s. per lb.. It was then drunk as in China to-day, that is, as a weak infusion without milk or sugar, and the habit grew to such amazing proportions that by the end of the eighteenth century it was an established drink among all classes. It has been said that the enormous consumption of tea was a source of anxiety to the brewers. Well it may have been, but, if it caused a certain diminution in the abominable addiction to spirits, gin mixtures and beer, it did well, for the drinking habits of the people of England during the eighteenth century were causing untold misery, illness and such general squalor that the terrible picture of Hogarth's "Gin Lane" is a revelation as true as it is appalling. While some regarded the excessive drinking of tea as harmful, almost as iniquitous as gin drinking, others were of the opinion that by "tea drinking and regular living, the Distemper of England (i.e. scurvy) may be cured". With these two developments in dietary habits both tea and sugar rapidly became the cheapest of foods, and the consumption of coffee, cocoa and chocolate was markedly reduced, with the result that the famous coffee houses slowly disappeared.

Throughout the Victorian era the nutritive value of British diets was good for those who could afford an adequate diet, bad for those who could not. It has been authoritatively stated that at the end of the nineteenth century the dietary "and the material state of our working people was probably worse than it had been since the great famines of Tudor times". Had the poorest classes in the second half of the century not been eating bread made from stone-ground flour, one can hardly imagine what their fate would have been. Amongst the middle classes the diet of porridge, bread, butter and tea for breakfast, meat and potatoes or a greasy vegetable stew for dinner, with a supper of cheese and beer, may appear, at a superficial glance to be sufficient, but when the calorific value, the mineral and vitamin contents of these diets are calculated, there is no doubt as to their insufficiency. They lacked, sometimes in terrible measure, those factors which go to the building up of strong, healthy bodies in children and adolescents.

In any discussion of the dietaries at this dark time in English industrial history, we must clearly differentiate between farm labourers in the south of England and those in the north of England, Scotland and Ireland, as also between the artisan classes and the poor labourers who dwelt in the slums of great cities and small towns. The farm labourers of the north of England, Scotland and Ireland stood literally head and shoulders above all other classes, for the simple reason that they lived principally on wholemeal, milk and vegetables.

That these facts are true and that food in relation to physical fitness is not only an individual matter but one affecting the state of health and efficiency of the nation, is revealed in the available statistics concerning the height and weight of men, women and children. Medical examinations of recruits in war-time indicate fairly accurately the state of physique of the nation. In 1870 the minimal height for infantry recruits was 5 ft. 6 in. In 1883 it was reduced to 5 ft. 3 in.; in 1900, at the time of the Boer War, it was 5 ft. 0 in.! A Government Board of Inquiry instituted at this time by the Army Medical Authorities, on which the Royal College of Physicians and others were represented, came to the conclusion that since army rations contained a sufficiency of protein—125 grams per day—and of carbohydrates, and gave 3500 Calories per day, the fault could not be attributed to diet. A comparison of the nutritive values of a diet of white bread, butter, sugar, meat and tea or beer and that of a diet of bread and butter with milk and oatmeal in abundance will give the answer to the problem which went unsolved in 1904. It will show why London Military Authorities in 1900 favoured recruiting campaigns in the north of England, Scotland and Ireland. In the North, men of the countryside were bigger and stronger in those days because they had in their diets not only calories but an adequate supply of foods rich in vitamins and mineral salts. In this connection it may be observed that, according to Sir Thomas Middleton, "the peasantry of the Scottish Highlands, physically perhaps the finest of British races, until recent years consumed very little meat; their staple foods were oatmeal, milk and potatoes with herring and other fish in coastal parishes". Unfortunately for us as a nation the dietaries of the great mass of the people have become more refined and lack, to a considerable extent, the essential nutrients in which the coarser diets are so rich.

In 1900 Seebohm Rowntree published a book called *Poverty: A Study of Town Life.* The town was York. The book is a classic in the literature of social economy. Its birth was naturally heralded at the time: it required a decade for the facts in it to arouse attention to the conditions in the slums of our large cities, where infantile mortality approached the appalling figure of 250 per 1000.

From such publications it was slowly forced upon us that the evolution of dietary habits was progressing along two clearly demarcated lines; one good, the other bad. Repeated examination of the latter showed that a too large section of the people of this country was undoubtedly suffering from malnutrition.

The food habits of the people of the United Kingdom have changed to the benefit of many; they had, until the present emergency, remained unchanged to the detriment of not a few. During the past five years we have learned how the benefits of wholesome food can be made available to all. If the most vicious expression of war's aftermath—hatred, prejudice and unrest—is to be avoided, the people must be adequately fed, housed and clothed. All bodies responsible for Food, Agriculture and Education must continue to inform parents and others of the value of food and, above all, our schools must not fail in their duty to train children in the elements of nutrition.

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CHAPTER II

THE PROBLEM OF WORLD MALNUTRITION

The problem of world malnutrition is one of the most crucial tasks facing mankind to-day. It may not be too much to say that upon its satisfactory solution will depend the future peace of the world. At the Hot Springs Conference in U.S.A. (May-June), 1943, statesmen, scientists, economists and others discussed the various needs of world populations and set forth fundamental principles and general plans necessary to bring the world's food supply up to the level demanded by the generally accepted standards of nutrition. The problem is far greater than a mere increased production and a better distribution of food. Its ultimate implications are political, its present basis is the science of nutrition.

" Scientific discoveries in nutrition have shown how we can build a race of sturdy children, how we can see to it that the next generation will be as ignorant of the diseases which afflict us to-day as the present generation is of the epidemics of cholera and smallpox, malignant scarlet fever, etc., which were the terror of our forefathers." But scientific discoveries in nutrition would not be so rapidly effective were it not for advances made in other fields of social science. The Industrial Revolution brought in its train a gross indifference to darkness and to dirt, and an acceptance of conditions of human living which formed the basis of a pitiable nutrition. When the Romans invaded this country they brought with them certain ideals in cleanliness which were exemplified in the construction of famous baths. The Roman bath by a process of degeneration became in this country the public bath house, at first a most necessary if not entirely faultless institution, but with its passing there disappeared from England " an institution which filled a communal need for sweating, steaming, sociability and scandal ". Bad though the bath houses ultimately became they could not match the depravity of the gin houses of Hogarth Lane, that prototype of the most disreputable, depraved and degrading conditions of life in the early days of industrial expansion in this country. While such conditions have passed it could never be claimed that good food or better feeding was the major

factor in their passing. Good food demands the means to buy good food, and this financial basis is not one of high salaries but of salaries proportionate to the cost of living or the achievement of an adequate standard of life, and this in turn depends upon a stable economic system.

In the midst of the increasing interrelatedness of all things in a rapidly constricting world it is difficult to see how any economic system can secure for all mankind a decent standard of life unless it be created on an international as opposed to a national basis. The problem of the nutritional needs of the world as a whole can only be solved by international action. Let us look generally at the nutritional state of the world and then follow our statement by a brief summary of the plans envisaged for the relief of the millions of underfed people in Europe, Asia, Africa and America.

THE EVIDENCE OF MALNUTRITION

There are few countries in the world where social and public health services are so well developed or where there has been a more marked improvement in health and physique as in the United Kingdom. There was, however, in 1938, still evidence in this country of malnutrition in 25 to 30 per cent of the population. Nevertheless, that after five years of global warfare we as a nation were in remarkably good health simply showed that scientific advice freely taken will ultimately solve the problem of malnutrition in so far as food is concerned. It is, however, countries other than the English-speaking ones which present the most difficult aspects of the problem. To-day the diets of the great majority of the populations of Eastern and tropical countries are grossly deficient when judged by scientific standards.

India.—A great deal of highly scientific work on Indian diets has been carried out, and has been well surveyed by Dr. Aykroyd of the Conoor Research Institute. There can be no doubt as to the relationship between diet and the incidence of disease in India. The main dietary defects in India are a too high proportion of cereals, with accordingly a too great consumption of carbohydrates, and a deficient intake of protein—particularly first class or animal protein—fats, minerals, and vitamins. "India is a land of poverty in the midst of wealth, of social

prejudices, irrational customs, and widespread ignorance." The presence of goitre, macrocytic anæmia, epidemic dropsy, beri-beri, amœbic dysentery, and lathyrism can be largely attributed to dietary deficiencies. The use of milled rice which has been deprived of vitamin B_1 is an important factor. Parboiling rice is of value in that such treatment causes the diffusion inwards of the water-soluble vitamins from the outer layers of the grain. It is interesting to know that in the Provinces of Assam, Bihar, Orissa and Hyderabad 75 to 90 per cent of the rice-eating population consume it in the home-pounded state, which contrasts most favourably with the machine milling and polishing so common in other districts, particularly Madras.

In India, with its vast population of 400,000,000, a large proportion of the people, with respect to their dietaries, never approach physiological requirements. The Hindu population is largely vegetarian, the higher castes rigidly so; the only animal protein they consume is in milk. Moslems and Sikhs have a much better supply of animal protein in that they eat certain meats, fish and eggs, in addition to whole grains, vegetables and fruit. Deficiency diseases such as keratomalacia, the commonest cause of blindness in Southern India, beri-beri, osteomalacia in women, due not only to food deficiency but to the social custom of purdah, create major public health problems in certain areas. In India 50 per cent of the total mortality occurs in children under ten years of age, that is five times greater than in the West. Probably the most important advances which could take place in India would be to increase dairy farming and place agriculture on a sound scientific basis.

China.—In China there is unfortunately widespread malnutrition. The high incidence of tuberculosis and rickets, the low resistance to infectious disease, the high infantile death-rate, and the heavy parasitic infestation of the people are evidence of a very low nutritional state. As in India so in China, the development of dairy farming would be a great step forward. Chinese diets are characterized by a preponderance of cereals, a low percentage of animal protein and a lack of milk. Among staple foods, rice occupies the first place in the south, wheat and kaoliang in the north; other cereals are millet and maize, of which fairly large amounts are consumed. On the coast, however, the situation is better, because fish and other sea foods are available as sources of animal protein.

Although China was one of the most important egg exporting countries, yet even in families of well-to-do farmers in North China, where the consumption of eggs is highest, the average consumption does not approach one egg per head per week. Milk consumption is negligible, and there is considerable prejudice against its use.

Africa.—In tropical Africa there is abundant evidence of malnutrition and deficiency disease, which is true of all tropical areas. Little or no milk, a low meat consumption and an excessive starch diet mean a lack of body-building proteins, mineral salts, vitamins and fats, all so essential if the human body is to approach its maximal or optimal efficiency. While one can find some excellent specimens of African natives, Zulus and meat-eating Masai, they are in a great minority, and the picture of the African of great and noble physique built upon a dietary of undamaged natural products may still be found in books and, speaking in general terms for Africa, unfortunately nowhere else.

South America.—The problems of nutrition are being attentively studied by the International Labour Office with the aim of framing a common policy on nutrition for adoption by the different States of South America. The situation varies greatly in the States of Latin America, being in general terms most satisfactory in Argentina, and least so in Chile and Peru. For example, in Argentina and Mexico there is a fairly good consumption of milk and milk products, eggs and butter ; in Colombia and Chile it is very low, especially among manual workers. We would expect meat consumption to be high in Argentina, and it is just twice as high (148 kg./yr.) per unit of consumption as it is in any other country in the South American continent (40–80 kg./yr.). In Latin American countries there is a considerable consumption of corn (maize). While there is a deficiency of protein in the eastern states, the serious deficiencies in protein, vitamins and minerals are found in the West or Pacific states.

UNEQUAL DISTRIBUTION OF FOODSTUFFS

Milk.—A decade ago the liquid milk equivalent, that is, milk in all forms and its products, cheese and butter, consumed in Britain amounted to about 700 pints per head per

year. In U.S.A. approximately the same amount was consumed. In New Zealand and in Switzerland the consumption was about 1000 pints per head per year. If we accept the decisions of nutrition experts with regard to the amount of milk and milk products which should be consumed, then in Britain the amount should be increased by at least 30 per cent. But in Poland, pre-war figures show that the average consumption was about 400 pints per head per year; in Italy 183 pints. Figures are available for the consumption of fresh milk. As one passes from the pre-war favoured nations of Europe and America to South East Europe, South America, Africa and China, the unequal distribution is all too apparent. As to China, Africa and India the figures are not reliable but one can say that the Chinese coolie who gets one half of a pint of milk per week is well off. In India one need only see the quality of the milk and note the almost negligible amounts used to realize how pitiably lacking in this valuable article of diet the Eastern peoples are and how totally inadequate would be even a 200 per cent increase in milk production. The story is almost the same for eggs and butter and the unfortunate fact to be faced is, that an immediate increase in dairy products in Asiatic countries is out of the question. Still these facts remain as a tragic indicator of the dire need of these peoples.

THE POSITION OF CEREALS AND POTATOES IN HUMAN DIETS (BENNETT, 1941).

Percentage Calories from Cereals and Potatoes	Countries	Total Population, Millions
30 to 40	U.S.A., U.K., Canada, New Zealand, Switzerland, Sweden, Austria	205
40 to 50	Germany, Denmark, Holland, Norway, Australia	93
50 to 60	Eire, France, Belgium, Baltic States, Czechoslovakia, Argentina	93
60 to 70	Portugal, Spain, Italy, South and Central America	204
70 to 80	Poland, Bulgaria, Yugoslavia, Egypt, Japan, Algeria, Tunis	156
80 to 90	Roumania, China, India, rest of Africa, Russia (position not accurately known)	1344
	Total	2095

Cereals.—A similar situation obtains with regard to cereals upon which most of the world's population depends for the major part of its supplies of human energy. The energy foods, so called because of their large starch or sugar content, are rice, wheat, maize, oats, rye and potatoes.

Some interesting facts emerge when one considers the pre-war production and consumption of cereals and potatoes (Bennett, 1941) (see previous page).

It is clear that the use of cereals must not be regarded lightly. When they form approximately 40 per cent of the energy source and are accompanied in the dietary by a sufficiency of meat, sugar and fat, they are, particularly the whole grains, excellent sources of vitamins and mineral salts. But when they bulk too largely in the diet they are evidence of a low standard of living and an inability to obtain or to purchase other necessary foods.

Rice.—In India, China, Japan and the East Indies some 87,000,000 tons of rice were produced in 1936. This is the staple diet of some 700 to 800 million people and only two million tons were exported, mainly to European countries. This means that on an average 0·75 lb. of rice is consumed per head daily and this provides approximately 1340 Calories. The staple diet provides about half the energy which we would expect would be expended by the average peasant. That there is a deficiency in calories and nutrients one can well understand. It has truly been said of India that " there are always three mouths for every two rice bowls ".

Sugar.—As a further example of uneven distribution due to the competitive trends in world trade we may take the production and consumption of sugar. In 1936, the great sugar producing centres, the Caribbean and the East Indies, placed some 6,000,000 tons of sugar on the world market. In that year Britain and the U.S.A. consumed 5,000,000 tons! These two countries contain one-tenth of the population of the world and they utilized 83 per cent of world sugar production! And the tale is the same for fruit, oils and fats; the favoured peoples, those of the North American continent, the British Commonwealth of Nations and the Western countries of Europe with the exception of Spain and Portugal have, or rather had, previous to the war of 1939–45, full control of the world's markets.

There are several factors which prevent an even distribution of food and are therefore productive of a bad world nutritional status. Some of them are fear of, or the desire for, aggression, leading to the uneconomic employment of human and natural resources, the expenditure of large sums of money on armaments and the creation of barriers to international trade. Freedom from want may certainly be the forerunner of freedom from the fear of war and economic insecurity. In our generation the world has been obsessed by fear, fear of aggression, fear of social and economic insecurity. When in the future the fear of military aggression has gone, progress towards the goal of the four freedoms will be retarded if a spirit of opportunism, in political and economic life, is permitted full sway. To plan successfully for the removal of world malnutrition, certain unpalatable facts must be faced by the favoured nations of the world, particularly the British and the American. The difficulties of the problem for heavily importing countries have been clearly set out by Mr. Le Gros Clark from whose paper, " Hotsprings and Humanity " the following is quoted :

" With the exception of the United States, all meat, butter, and fruit exporting countries have small populations. Several of them have a fairly high level of consumption of the foodstuffs in which they deal. But the main importing countries also cover between them a very small percentage of the world's population. Omitting the United States, which only enters the market significantly for sugar, vegetable oils and some fruits, we find that a large proportion of the overseas trade in foodstuffs is diverted to about 7 per cent of the world's consuming public. Thus, some 10 per cent to 15 per cent of the world's population appear to be engaged in distributing among themselves the large bulk of the annual reserves of meat, sugar, fruit and dairy products. There is no reason why a very fair proportion of this relatively small surplus of food should not pass to the Balkans, South America and China.

" Yet it only requires to raise the effective demand in China by 10 per cent to make China a competitive importer of Javanese sugar, Australian beef, and New Zealand butter.

" It is necessary to grasp the fact that a number of the food exporting countries reject their foodstuffs, not because their population is already overfed, but because they need to purchase raw materials, textiles or machinery. In some instances, as

with Burma, Cuba and Jamaica, they have neglected stock-raising and vegetable culture for their own subsistence, in favour of the mono-culture of rice or sugar or bananas. Under a more wholesome economy they would divert some of their labour to the adequate feeding of their own people. At the other extreme, there are perhaps five or six exporting countries who could in the immediate pre-war years boast that they still retained within their borders a sufficiency of food for the whole population; these true surplus exporting countries are Denmark, Canada, Australia, New Zealand and possibly Argentina and Uruguay. Even in these countries the diet of the poorer classes often leaves much to be desired. As for the small food-exporting countries represented by Algiers, Turkey and South Africa, it is doubtful how far they would remain on the world market if they so adapted their economy as to provide first for the needs of their own inhabitants.

"South Africa has a population of about 10,000,000 of whom some 2,000,000 are of European stock. South Africa produces sufficient fruit to supply her whole 10,000,000 inhabitants on a fair basis of adequacy, but her normal yearly export of fruit reduces the domestic supplies so far that sufficient remains for no more than 5,000,000. The country might have had butter enough for 3·5 millions; but normal exports reduce the possible consumers to a level of 2·6 millions. An already insufficient supply of meat, fish and eggs is still further restricted by the export policy."

Planning for an Equitable World Food Distribution.—Planning for the abolition of world malnutrition demands the closest collaboration of nutrition, public health and agricultural authorities. This collaboration, varying from purely scientific research to the intricacies of economic readjustments, must be on an international scale. Planning for the greater production and better distribution of food, which should be considered with other forms of production and trade, must be based on modern scientific knowledge of human dietary requirements. Since we know the requirements, we can determine the needs of a population for health in terms of the more important nutrients; and since we know where the dietary need is greatest, we can plan for the necessary production and equitable distribution of adequate food supplies. The great variety of the foods of the world can be classified into cereals, milk, eggs, butter and

fats, meats, vegetables and sugar. The determination of the absolute amounts of the more important nutrients requires a knowledge of the distribution of infants, children, pregnant and nursing women and occupational groups within the population and a translation of their nutritional requirements into terms of foods. It also requires that certain essential foods and supplements be made available for the vulnerable groups, i.e. infants, children, nursing mothers, invalids and the aged. It is also necessary to secure data concerning the amount of food produced within, and also the amount imported into, a country. Following upon the decisions as to the accepted balance between home produced and imported food will come one of the main parts of the whole problem, namely to make it possible for all consumers to secure an adequate and suitable supply of food. If these fundamental points be applied to all nations it will readily be recognized how this problem of world malnutrition will depend for its solution on a world wide policy of expansion and, if necessary, a reorientation of industry and agriculture. This is where the task passes from the nutritional aspect into the wide and extremely difficult sphere of international or world economics.

At the United Nations Conference on Food and Agriculture (1943) it was recommended amongst many other things as a long-term production policy :—

(1) " that the inherent natural and economic advantages of any area should determine the farming systems to be adopted and the commodities to be produced ;

(2) " that each nation should direct its own policies towards increasing efficiency of production, encouraging the production of foods which are high in vitamins but relatively perishable, e.g. vegetables, fruits, milk, eggs and meat, and limiting the production of bulky, easily stored and transported energy foods ;

(3) " that to implement these aims, measures should be adopted to help producers to acquire materials, equipment and machinery and, equally important, to secure technical assistance ;

(4) " that for the immediate and successful solution of the new problems of agriculture, steps should be taken to develop education and research. It was recommended that each country should strengthen and expand the educational system of its

rural areas, train scientific workers and rural leaders for service in agriculture, and that each nation should adopt a policy of promoting research in all branches of science, including economics, which relate to food and agriculture."

The inadequacy, in many countries, of agricultural education and of research facilities is well known. If the people who live on the soil are to benefit by their work they must know the soil, and therefore it is most important that there be some strengthening and expanding of education in rural areas. Not only must there be a sound introduction to biological knowledge in secondary schools but an increase in facilities for rural adult education. Only by such preparation can we hope to promote technical efficiency in what we would hope will continue to be large farming communities and to develop a better understanding of rural problems. It has been definitely stated that each nation should adopt a policy of promoting research in all branches of science including economics which relate to food and agriculture. Nothing should be left undone which would promote research in the natural sciences and apply the scientific method to the numerous problems of food and agriculture.

This is but a brief survey of the situation and of the difficulties which will attend the realization of a greater freedom from want. The task is enormous and will demand goodwill, compromise and vision on the part of statesmen of all nations. The task is nothing less than that of harnessing social and political security to human welfare; its success may well prove to be the very basis of world peace.

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CHAPTER III

THE PROBLEM OF NUTRITION IN GREAT BRITAIN

By the end of the nineteenth century the battle for cheap food had been won, and in some measure, at the expense of agriculture in this country. While it could be said, in general terms, that the population of the United Kingdom did not suffer from hunger, there was still a large minority of the people who certainly did not secure an adequate diet. The impetus given to research in nutrition by the discovery of vitamins led to a practical consideration of the nutritional status of the people. The older conception of an adequate diet, namely that it must supply a sufficiency of calories and satisfy hunger, had given place to a consideration of quality translated into terms of nutrients necessary, not only for energy, but for the building of a structurally sound body. The newer knowledge of nutrition had in brief demanded new and more refined dietary standards. No longer was it a question of calories and protein but of calories, protein, vitamins, mineral salts and water. In the interim war period so decisive was the impact of this new knowledge upon the official mind that in 1931 a small committee of physiologists was appointed by the Minister of Health and the Secretary of State for Scotland to advise the Minister of Health " on the practical application of modern advances in the knowledge of nutrition ". Apparently impressed by the findings of this body, the same authorities, in 1935, appointed an Advisory Committee on Nutrition " to enquire into the facts, quantitative and qualitative, in relation to the diet of the people and to report as to any changes therein which appear desirable in the light of modern advances in the knowledge of nutrition ". This called for an investigation of the amounts of the various foods consumed by the men, women and children of this country, an opinion as to the adequacy or inadequacy of the national dietary, and suggestions as to the means whereby recent nutritional scientific knowledge could best be applied to the feeding of the people. In its work this Committee had

before it the Report on the Physiological Bases of Nutrition issued by the Health Committee of the League of Nations in 1936. Briefly, the conclusions of this important Committee in 1937 were: that in the *national food supply* there was no lack of energy-giving foods, carbohydrates, fats and proteins, but there existed a small section of the people who did not obtain adequate supplies of these, that is to say, there was a faulty distribution of essential foods.

The most significant finding was, however, with regard to milk. Taking the League of Nations recommendations as to human requirements, emphasizing the nutritional importance of milk, particularly for mothers, children and adolescents, the Advisory Committee stated, that "the present national consumption of liquid milk is less than one half of" the required amount, namely seven-eighths of a pint. If condensed and dried milk were also included, the national consumption was only 60 per cent of the amount suggested by the League of Nations Commission.

A comparison of the consumption per head per week of certain foods in the periods 1909–13, 1924–28, 1934–35, 1937–38, indicates how, despite marked deficiencies in food distribution, there has been a steady improvement in dietaries, an improvement which has resulted largely from the educational work carried out in schools and in health clinics, and particularly by means of the important publications issued by the health and education departments of the Government.

The general steady upward trends in food consumption are shown in Table 1.

In view of what has been stated about unequal distribution of food, and having regard to the significance of rationing during the 1939-45 war, it is of interest to note the foods which have come into greater consumption between 1909 and 1938. It will be noted that there is a steady and, in some cases, a marked increase in the consumption of certain foods; they are eggs, fruit and vegetables, butter and margarine. The foods, the increased consumption of which rises progressively with income, are those which are both the most expensive and the most important for health, namely, eggs, fruit and vegetables, butter, fresh milk and meat.

As a result of numerous dietary surveys in Britain, Australia, New Zealand, U.S.A. and the continent of Europe, it has been

shown that in the 1930–35 period varying percentages of the people in the countries investigated suffered from an inadequacy of food supply. It has been shown by Sir John Orr in his book, *Food, Health and Income*, published in 1936, that in the United Kingdom 30 per cent of the people did not receive that amount of food necessary for the supply of required amounts of protein, certain vitamins and minerals; if calcium requirement were

Table 1

FOODS CONSUMED PER HEAD PER WEEK. UNITED KINGDOM

From the First Report by the Advisory Committee on Nutrition, 1937, *and from* "Feeding the People in War-time," *by Sir J. B. Orr, F.R.S., and D. Lubbock*, 1940

	1909-13	1924–28	1934–35	1937–38
	lb.	lb.	lb.	lb.
Meat, including poultry	2·58	2·56	2·81	2·62
	pints	pints	pints	pints
Milk and cream	3·46	3·35	3·26	3·85
Condensed milk	0·05	0·14	0·23	
Eggs in shell	1·93	2·34	2·90	4·48
	lb.	lb.	lb.	lb.
Butter	0·30	0·31	0·49	0·48
Margarine	0·11	0·23	0·15	0·30
Cheese	0·14	0·18	0·19	0·18
Lard	0·08	0·11	0·18	—
Fish	0·79	0·80	0·87	0·87
Sugar	1·52	1·60	1·79	—
Cereals (+ wheat and flour)	4·45	4·41	4·04	4·06
Potatoes	4·68	4·43	4·25	4·24
Other vegetables	1·38	1·81	2·22	3·9
Fruit	1·19	1·75	2·23	—
Tea	0·12	0·17	0·18	—

the only standard by which diets are to be judged, then some 50 per cent of the population was deficient in this respect. Such findings were corroborated generally by the results of the survey made by Sir William Crawford in 1936–37. Pertinent to the present discussion is the amount of the important foods consumed by the six income groups into which the population was divided by Sir John Orr.

Table 2 represents a limited survey in a population of over 45,000,000 people. If data from very extended surveys covering all classes of the community were available, in which the average

TABLE 2

QUANTITIES OF FOOD CONSUMED PER HEAD PER WEEK AT DIFFERENT INCOME LEVELS IN 1152 FAMILY BUDGETS

From "Food, Health and Income," *by Sir J. B. Orr, F.R.S.*, 1936

	Group I	Group II	Group III	Group IV	Group V	Group VI	Weighted Average of Groups
Proportion of the population . .	10%	20%	20%	20%	20%	10%	—
Number of persons in the group: millions	4·5	9	9	9	9	4·5	—
Number of budgets	411	152	233	156	136	64	—
Average income per head per week .	up to 10s.	10s. to 15s.	15s. to 20s.	20s. to 30s.	30s. to 40s.	over 45s.	30s.
Average food expenditure per head per week . .	4s.	6s.	8s.	10s.	12s.	14s.	9s.
Beef and veal . oz.	9·5	11·5	11·7	11·3	10·2	9·5	10·8
Bacon and ham ,,	2·1	3·1	4·3	6·2	6·8	9·7	5·3
Mutton and lamb ,,	2·6	4·1	4·6	5·7	5·7	6·6	4·9
Other meat (*a*) . ,,	2·8	2·9	4·2	5·4	3·6	3·5	3·8
Total meat (*b*) . ,,	17·0	21·6	24·8	28·6	26·3	29·3	24·8
Bread and flour (excluding biscuits and cakes) (*g*) . oz.	64·5	62·0	63·3	64·7	54·6	47·7	60·1
Milk—fresh . pints	1·1	2·1	2·6	2·9	4·5	5·4	3·1
condensed (*c*) ,,	0·6	0·4	0·4	0·3	0·2	0·1	0·3
Eggs . . no.	1·9	2·8	3·7	4·8	4·7	5·2	3·9
Butter . . oz.	2·7	5·7	7·4	8·8	8·9	9·7	7·4
Cheese . . ,,	1·5	2·1	2·8	3·2	2·9	2·5	2·6
Margarine . . ,,	4·9	2·9	2·2	1·9	2·5	1·4	2·5
Tea . . ,,	2·2	2·5	2·5	2·8	2·5	2·1	2·5
Potatoes (*f*) . ,,	51·2	50·8	55·5	57·4	42·8	39·4	50·4
Lard, suet and dripping . ,,	2·5	3·4	4·5	4·7	3·5 (*e*)	3·2(*e*)	3·8
Fish (*d*) . ,,	2·4	2·6	3·9	5·4	5·9	8·1	4·6
Sugar purchased as such . . ,,	13·5	15·9	18·1	20·1	19·0	18·1	17·8
Jams, jellies and syrups . ,,	4·3	5·5	5·7	5·8	6·5	5·6	5·7

(*a*) Sausage, corned beef and pork only.
(*b*) i.e. the total of the four items above.
(*c*) In terms of liquid milk equivalent.
(*d*) Excludes fried and tinned.
(*e*) For the two middle class groups, lard only.
(*f*) Excludes purchased "chipped" potatoes.
(*g*) In terms of flour.

consumption of each foodstuff in each group, duly weighted in terms of population and man value of the families in these groups, it may be possible, given perfect statistical efforts, to expect a close agreement between the results so obtained and the figures representing the national average consumption of these foods obtained by dividing total supply by total population. This, however, is beyond the bounds of present possibility, because of inherent errors in both methods. Perfection in dietary surveys cannot be attained, if indeed it could be expected, even if carried out continuously throughout the year, for not only must climatic or seasonal changes be investigated, urban and rural populations be separately surveyed, but within these populations account must be taken of the sedentary, the manual and the heavy industrial worker and, with the numerous family groups, a further differentiation must be made between infants, children, adolescents, women, nursing mothers and old people. To expect a precise answer to the amount of food consumed per head per week of the population by determining the total food supplied to the people, is to ignore many factors, such as waste in transport, storage and delivery, which militate against any such accuracy. Such difficulties and such criticisms do not in the least detract from the value of this important work, for despite all difficulties and all criticisms, such surveys have given in the past, and during the present emergency, a remarkably clear indication of the food habits of the various communities which collectively make up the nation, and have pointed the way to the correct control of the nation's food supply.

THE IMPACT OF WAR ON THE PROBLEM OF NATIONAL NUTRITION

It is an oft-repeated statement that it has required a world war to show us how to grapple with the problem of feeding the nation. To feed a nation properly, simply means to make available to all classes of the people a diet adequate to keep them in a fit state of health, and this means that energy foods must be available to enable heavy workers to perform the various duties to which they may be called, and that protective foods must be made available to the vulnerable groups; these are infants, children, adolescents, pregnant women and nursing mothers,

When a country such as ours faces as it did in 1915, and even more seriously in 1940, a submarine menace calculated to cut off all imported foods, its Government has to take steps immediately to increase to the maximum the home production of food.

The War of 1914-18.—During the first two years of the 1914-18 war there was little change in the food supply, but when by the close of 1916 Britain had lost 2,000,000 tons of shipping out of a total of 17,000,000 tons and had only a third of the tonnage available for the transport of food, then regulations were enacted to ensure the increased growth, the importation and equable distribution of vital supplies. It was not until 1917 that Lord Rhondda, as Food Controller, fixed maximum prices for certain foods for producers and retailers and also controlled the distribution of essential home produced and imported food supplies. The first foodstuff to be controlled by rationing at 8 oz. per head per week was sugar. Other foods such as butter and margarine were not controlled until considerable hardship, caused by unfair distribution, roused local authorities to arrange, through Local Food Committees, schemes of public distribution. It was not until 1918 that rationing was made compulsory throughout the United Kingdom. It was a long, tedious and at times anxious experiment in food control, the results of which proved of great value when we were again faced with the vital task of feeding the nation in time of war. The details of the experimental procedure during the war of 1914–18 are given in *Food Production in War*, by Sir Thomas Middleton, and in *Food and Planning*, by Professor J. R. Marrack. In essentials the food control policy was based on the control of bread, sugar, meat and milk. In 1916 a Wheat Commission was responsible for carrying out the bread policy of the Government. For scientific advice the Commission had the services of the Food (War) Committee of the Royal Society, a group of physiologists, biochemists, statisticians and agriculturists. The policy of the Government demanded three things, namely ; a greater home production of wheat, a higher extraction of the wheat berry and a greater dilution of wheat flour. Home production was increased from 1·6 million tons in 1914 to 2·4 million tons in 1918. From a 76 per cent extraction in 1916, wheat extraction was raised to 90 per cent in 1918. For the purpose of diluting

wheat flour, barley, rice, oats, maize, potato flour and even beans were used. From 1917 to 1918 dilution ranged from 15 to 30 per cent; the latter figure was an extreme limit which lasted but for a few months in 1918. The result of these methods was a 54 per cent increase in the amount of flour produced in 1918, extraction being responsible for 25 per cent and dilution for 29 per cent of the increase. The price of bread was also controlled by subsidy which amounted to £50,000,000 sterling per annum for three years.

Sugar, the first of all the foodstuffs to be controlled, was the special care of a Royal Commission from 1914 to 1918, and thereafter the supply was controlled by the American Food Administration. Before the war and before the control from the 1st January 1918, the amount of sugar consumed by the people of this country was approximately $\frac{3}{4}$ lb. per head per week. With rationing the amount was never less than 8 oz. per head per week. Despite labour shortage and bad weather, the potato crop was increased in 1918 by 20 per cent over pre-war figures, due to an almost 30 per cent increase in acreage. Carbohydrates were therefore well cared for during the first world war.

Because of the long sea lanes across which our meat has to be transported, it is not surprising that with 40 per cent of our meat imported and half of that from Argentina, the supply and therefore the consumption of meat fell in 1917 by 31 per cent of the pre-war figure of 1912–13. The imports of mutton and lamb from Australia and New Zealand suffered most. The ploughing up of grass lands and the scarcity of feeding stuffs for fattening animals were additional factors causing this marked fall in meat supply. This was the legitimate result also of the policy recommended by the Food (War) Committee of the Royal Society. Home produced meat was maintained at pre-war levels until the end of 1917, when, due to the causes mentioned, it fell in 1918 by about 33 per cent of the pre-war figure. Lack of supplies, high prices, and bad distribution forced the Ministry of Food to undertake the control of meat supply by rationing which was instituted in 1918 and was not stopped until December 1919.

Bacon and ham are extremely valuable foods, giving a very high calorie value. Two-thirds of these foodstuffs were imported, about 60 per cent coming from Canada and U.S.A.,

but these imports rose above the 1913 level by 40 per cent in 1915 and 60 per cent in 1916, fell a little in 1917 and rose again in 1918 to 100 per cent of the 1913 figure.

In view of the importance of the supply of *liquid milk* in the 1939–45 war, it is of interest to note briefly the changes in milk supply during 1914–18. No great change occurred in the number of cows but the supply of fresh milk fell some 15 per cent in 1917 to 25 per cent in 1918. Dried milk, of which previously only small amounts were produced at home, was so greatly increased that in 1917 as much was home produced as had previously been imported, and by the end of 1918 that amount had been doubled. As a result of high prices (5d. per pint) the poorest income groups did not obtain adequate supplies, and ultimately by the Milk (Mothers and Children) Order (February 1919) local authorities could supply milk free to children under 5 years of age and to pregnant women. This was a permissive regulation and, like many, if not most non-enforced laws and regulations, was very unsatisfactory.

Butter and margarine showed interesting changes in supply and consumption. In 1913 the consumption of butter was 4·9 oz., that of margarine 1·76 oz. per head per week. In view of the large amount of butter imported, approximately 90 per cent before the war, a fall of 50 per cent in consumption by 1917 was not altogether unexpected. Margarine, of which about half was imported, continued to be imported until 1918, when it was stopped, the importation having fallen rapidly in 1917. Home production was, however, greatly increased, so that in 1918 the consumption had risen from the 1913 figure of 1·76 oz. to approximately 3·50 oz. per head per week. The doubling of the margarine consumption, which at that time contained no vitamin A, offset to some extent the loss in energy value due to the fall in consumption of sugar and butter. Total calories fell but little—about 4 per cent. The greatest loss was in animal protein which reached the low unsatisfactory level of 25 grams per head per day. Total protein viewed from the present-day standard was low at an average of 69 grams per head per day. Since methods for the estimation of vitamins during 1914–18 had not the accuracy of those of the present day, it is clear from dietary surveys that there must have been a deficiency in vitamins A and D. The anti-scorbutic vitamin C probably suffered the same vicissitudes as it has done from 1940 to 1945.

In view of present-day knowledge, it could not have reached satisfactory levels. Viewing the situation as a whole, one may safely conclude that the initiation of food control was too long delayed and that the success of the rationing schemes was largely due to the fact that bread rationing had been avoided. It was this that enabled the country to face with fortitude the serious dangers of March and April 1918. A year before, errors made by the Germans in estimating the harvest yields and a failure to control strictly all rationing, showed the world how quickly "the will to win" can give place to a demand for "peace at any price".

Those especially concerned with the food problem realized, if others did not, that the home front was as important as any other front. The future, unfortunately, was destined to give further corroboration of this fact.

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CHAPTER IV

THE PROBLEM OF NUTRITION IN GREAT BRITAIN (*contd.*)

THE FOOD SITUATION DURING THE WAR, 1939-45

THAT the experiment in food control during the first Great War bore not a little fruit is shown by the activity of the Board of Trade in setting up in 1937 a Food Department, the precise function of which was to investigate the most effective means for the supply and distribution of cereals, meat, butter, bacon and sugar in the event of a major conflict in Europe. Initial activity, however, was not the earnest of a continuing purpose designed to place this nation in a food position strong enough to face, with some degree of equanimity, the appalling danger into which it was soon to be placed by a ruthless submarine campaign. Immediately upon the declaration of war in September 1939, there was established, under Lord Woolton, a Ministry of Food which was to prove one of the most successful of all War Ministries. Realizing the importance of the morale of the civilian population in fighting a total war, the Ministry, through various Scientific Advisory Committees, decided upon a food policy flexible enough to meet the ever changing vicissitudes of war, but having one all important aim, the adequate distribution, to all classes of the community in accordance with their physiological requirements, of those foodstuffs deemed essential to the maintenance of bodily health and vigour. With rapidly growing armies and a tremendous increase in industrial activity, the like of which this country had never seen, the problem became essentially one of limited importation and maximal home production of food. The Ministry assumed full control over the purchase and distribution of essential foods for human consumption and feeding stuffs for live stock. The effective handling of this vast problem was made possible by the integration of the work of numerous Advisory Committees representing shipping, industry, agriculture and medical science. Local Food Committees and Food Advice Centres were formed, British Restaurants and Canteens were established in industrial areas, and, by means of numerous publications, statements in

the daily Press and announcements on the air by the British Broadcasting Corporation, much valuable information on what to grow, what to eat, and how to cook it, was imparted to the general public.

The crux of the problem of maintaining the physical and mental fitness of a nation is food distribution. Without an adequate diet available to all, no nation can be expected to survive the crisis of a great war or hope to become socially progressive or politically stable. Effective distribution demands control from the centre, a control which fixes the price of essential foods in accordance with the standard of living and determines the ration of any food per head per week in accordance with the physiological requirements of the people. And the people are composed of mothers, infants, children, adolescents, men and women employed in various activities, invalids and old people. All these groups have different needs, in terms of energy and of body-building foods ; they must therefore be catered for on the basis of a scientific knowledge of their physiological needs. Present-day knowledge of these physiological needs was quite sufficient to guide the Ministry of Food in developing their system of rationing whereby food control was exercised.

THE RATIONING SYSTEM

The scheme of rationing was based upon the issue of coupons whereby the retailer supplied, and the customer obtained, rationed foods against the appropriate coupons. Rationing was operated on either a per head weekly or a four-weekly basis. This was begun on the 8th of January 1940 with butter, bacon and sugar. While the ration of bacon ranged from 4 to 8 oz. per head per week, it was mostly held at 4 oz. Butter and margarine (the latter included on 22nd July 1940), with short-lived exceptions, were rationed in the amounts of 2 and 4 oz. respectively, with cooking fats at 2 oz. For the Christmas week 1944 the margarine ration was raised to 12 oz. Sugar rationing commenced with 12 oz. per head per week. On certain occasions, as for the weeks preceding Christmas, a special additional ration of 4 oz. in 1940 and 1941 and 8 oz. in 1944 were made, and on other occasions the sugar ration was exchangeable for preserves, in 1943 the rate being 1 lb. of sugar for 1 lb. of preserves and in 1944 1 lb. of sugar for 2 lb. of preserves. During 1940 meat was

rationed at an average of 1s. 10d. per head per week; in 1941 it was valued, on an average for the year, at 1s. 2d. per week. The cheese ration suffered considerable variation; in 1941 it varied from 1 to 3 oz. per head per week; in 1942 it was 4 oz. for the first half and 8 oz. for the second half of the year; for the greater part of 1943 it was 3 oz. and in 1944 it was 3 oz. in the winter and 2 oz. in the summer and early autumn. A special ration of cheese was made available for certain classes of workers, to whom canteens and British Restaurants were not available, such as agricultural workers, miners, fishermen, forestry workers, etc. Vegetarians were given extra cheese rations in lieu of meat and bacon. From 5th May 1941 their ration was 8 oz. per head per week; in December 1941, 12 oz.; on the 26th July 1942 it was again raised to 16 oz. and returned to 12 oz. on 10th January 1943.

In December 1941 a system of points rationing was introduced whereby the consumer could purchase within a period of four weeks certain foods wherever obtainable. These "points" covered at first canned meats, beans and fish, but later they were made to cover a wide range of foods.

An interesting feature in the distribution of essential foods by the Ministry of Food was the control, through priority groups, of milk, eggs and oranges.

Milk.—Under a National Milk Scheme, beginning 21st July 1940, expectant mothers and all children under 5 years of age were entitled to 7 pints per week. Children and adolescents, from 5 to 18 years of age, received 3½ pints per week, and all children between 5 and 14 years who could not attend school, were allowed 5 pints per week as from 6th October 1942. Invalids could, on a doctor's certificate, receive up to 2 pints per day. The Milk in Schools Scheme whereby on school days all scholars, if they so wished, could receive one-third of a pint of milk at the cost of ½d., was already in force. To non-priority groups no definite quantity of milk was guaranteed. Important in the plans of the Ministry of Food for the economical distribution of milk was the nationalization of milk distribution in 1942 by the zoning of deliveries in towns with a population of 10,000 or over.

In view of the increased demand for milk and despite increased production and limited supplies of fresh milk, National Household Milk powder was made available during

the winters of 1942–43, 1943–44 and 1944–45. National Household Milk was made from spray dried skimmed milk ; the distribution was based on sugar registration and the allowance was one tin to each customer in two four-week periods : one tin contained the equivalent of four pints of milk.

Eggs.—Under the Egg Control Scheme, put into operation in June 1941, consumers had to register with a retailer for shell eggs, allocations of which were made from time to time. Priority classes for shell eggs, first introduced on 17th November 1941, were nursing and expectant mothers, infants from 6 to 18 months and invalids : they received 4 eggs per week. A year later the number of eggs was reduced for priority classes to 3 per week, children under 5 years of age to 1 per allocation.

The shortage of egg supply led to a controlled distribution of dried eggs from 24th June 1942. On 7th March 1943 priority was granted for infants between 6 and 18 months but not for infants under 6 months of age, at the rate of 3 per week. One packet of dried eggs, equal to 12 eggs, was given per allocation to each customer registered for shell eggs.

Oranges.—In the interests of children of 6 months to 2 years and of expectant mothers, cod-liver oil and orange juice were made available through various food centres from the beginning of 1942, and priority distribution of oranges was undertaken to limited areas as supplies were received. With the close of the German war, supplies increased and by September 1945 the supply by allocation of oranges to the public became more frequent.

As preserves, jam, marmalade, syrup and treacle were rationed from 17th March 1941 ; on 26th July 1942 syrup and treacle were transferred to the points scheme of rationing. As required, either additional sugar for the making of jam was released or the preserve ration became interchangeable for sugar at the rate of 1 lb. of preserves for 1 lb. or 8 oz. of sugar.

To determine the efficiency of this method of control of essential foods, the consumption and expenditure per head per week of all the foodstuffs which made up the average war-time diet were noted by dietary and budgetary surveys carried out by several bodies, such as the Ministry of Food, the Ministry of Health, the Combined Food Board of the U.S.A., Canada and the United Kingdom, the Department of Health for Scotland and the Oxford Dietary Survey.

In the United Kingdom, the value of rationing was soon apparent. By the winter of 1940 there was a marked fall in the consumption of meat, poultry and fish, sugar, fats and fruit. This meant a loss of valuable nutrients particularly of animal protein and fats. The fall in sugar was largely offset by a rise in the consumption of bread and potatoes. The period of greatest food shortage was in the first six months of 1941 when, due to the reduction in sugar to 8 oz. per head per week, preserves to 8 oz. per head per month, and edible fats to 8 oz. per head per week, the amount of supplies moving into civilian consumption were equivalent to approximately 2680 Calories, 33 grams of animal protein and 105 grams of fat per head per day. At this time dietary surveys showed that, in approximate figures, heavy workers were receiving diets which gave them 2627 Calories, 77 grams total protein, 28 grams of animal protein, 380 grams of carbohydrate, 81 grams of fat, and 720 milligrams of calcium. Lower income groups were receiving about 300 Calories less, due mainly to restrictions in sugar and fat, and their inability, during a time of great stress and strain, to make full use of rationed and unrationed foods. Improvement was apparent late in 1941, when lease-lend supplies arrived from the U.S.A. and was maintained by increased home production of vegetables, potatoes and fresh fruit as also by the increase in the extraction of flour to 85 per cent. A steady increase in the amount of milk and milk products consumed, also added to this improvement by increasing animal protein and calcium. In 1942, surveys showed heavy workers receiving 2647 Calories, 86 grams total and 35 grams animal protein, 349 grams of carbohydrate, 93 grams of fat, and 820 milligrams of calcium: the chief deficiencies still being in Calories and vitamins A and C.

Interesting as a comment on national economy in the handling of food is the closeness of the average figure representing Calories as consumed (2650) to that representing Calories passing into civilian consumption (2800) (Table 3B (1942)). On practical grounds it may be broadly stated that, viewing the experiment in national feeding as a whole, a food equivalent of 3000 Calories per head per day should pass into consumption and that, allowing a margin to cover losses in the distribution and cooking of food, 2800 Calories per head per day should represent the amount of food eaten.

If all children had been enabled to obtain midday meals in school and had women with children been afforded the facilities of more extensive war-time nurseries and, using these, had fed daily at a British Restaurant or a work's canteen, then with the exception of the lower income groups, the adequacy of the war-time dietaries would have much more closely approached minimum requirements. Certainly the nutritional condition of a beleagured nation required constant vigilance on the part of the medical authorities. The approach to minimum nutritional requirement could only be viewed with a sense of satisfaction in view of the perilous state in which we were living. But it must be admitted that no diet which is characterized by monotony, difficult planning, uncertain shopping, and is not enlivened by a freedom of choice, can be regarded as wholly adequate, no matter how perfectly it may meet the required standards for Calories and nutrients.

DETAILS OF FOOD CONTROL AND COMPARISON OF RESULTS

In carrying out dietary surveys month by month from 1942 onwards, the Ministry of Food placed essential foodstuffs in twelve categories. These were :

Fats—butter, margarine, lard, cooking fat, suet and dripping.
Sugar and Preserves.
Beverages—tea, cocoa, coffee.
Milk—fresh liquid, national school, skimmed, condensed whole sweetened and unsweetened, condensed sweetened skimmed, dried whole and dried skimmed.
Cheese and *Eggs*—shell and dried.
Meat—including bacon and ham.
Other Meat and Meat Products—liver, kidney, poultry and game ; canned and prepared meats, sausages and cooked meat.
Fish—fresh, smoked, fried and canned.
Vegetables.
Fruit—fresh and canned and dried.
Cereals—national brown flour, national bread, biscuits, buns, cakes, etc. Oatmeal and oat products, whole rice, sago and tapioca.
Breakfast Cereals other than oats—cornflour and custard powder.

About one hundred specific foods were checked. The trends in food consumption during the war can be sufficiently well indicated if the more important of these categories be examined (see Table 3).

Milk.—The policy of the Government was to encourage the production of fresh liquid milk. The amount of milk moving into consumption increased by 1944 to 36 per cent above the 1939 amount. Despite the increase in consumption from 3·30 to 4·49 pints per head per week there was in 1942 a marked diminution in the supply to non-priority groups. That the priority groups received their supplies at the expense of non-priority groups was sound national policy. Non-priority consumers made up their deficiencies by the use of condensed milk and dried skimmed milk (National Household Milk). The production of cream and ice cream was prohibited from 1941 until 1944. The steady upward trend in milk consumption is the more marked if one compares the consumption for the third quarter of the years 1941 and 1942; they were 2·7 and 3·2 pints per head per week respectively. In the winter quarters there was the usual seasonal fall in consumption. In 1942 a 30 per cent increase in the amount of milk supplied to priority groups was due to an increasing consumption of milk in schools and in households where priority milk was due. It is also noteworthy that at this time expenditure on milk supplies increased and less free milk was accepted, a situation arising from the increased amount of free money available. On 15th July 1945 milk for non-priority groups was reduced from 3 to 2½ pints per head per week. Before the war, condensed milk was used largely by working classes, dried milk almost not at all. When powdered milk was introduced, the highest economic groups were much bolder in experimenting with it than were the lower economic groups. This may have been due to the fact that in those higher economic groups, a greater use of fresh milk is made and, therefore, when milk became scarce, and feeling that milk should not be omitted from the dietary, the housewives did their best to supplement their diminished supplies of fresh liquid milk by means of dried milk. It has been stated that if the powdered milk had been of the highest grade of production and had not, therefore, lost too much of its fat content, the general public, if capable of making it up properly, would have been unable to differentiate

with any great degree of accuracy between reconstituted milk and fresh milk.

Cheese.—On 5th May 1941 the ordinary cheese ration was only 1 oz. per head per week, on 30th June, 2 oz. and on 25th August 1941, it had been raised to 3 oz. On 1st June 1942 the ration was 4 oz. and was raised to 8 oz. on 26th July 1942. The year 1943 saw it fall from 6 to 3 oz. During 1944 it was reduced to 2 oz. during the summer months and after being raised to 3 oz. on the 15th October 1944 it was again reduced to 2 oz. on 1st April 1945. Pre-war consumption of cheese was 2·7 oz. per head per week. During 1941 the consumption was 2·5 oz. and in 1942 it was 4·3 oz. per head per week ; during the ensuing three years it fell steadily to the pre-war level.

Eggs.—The lack of shell eggs was one of the major deprivations of the war. In 1935 the average number of eggs eaten was 3 per head per week of the population ; in 1937–38 the number was 3·4 ; in 1941 it had fallen to approximately 1, and in the winter months of 1942 it was one-fifth of an egg per head per week. Such a situation was not unforeseen, for the control of shell eggs came into force on 30th June 1941 and five months later priority supplies were announced for nursing mothers, children under 5 years and invalids. The "take-up" of eggs depended upon the number of allocations. In 1941 priority groups received 4 shell eggs per week, in October 1942 nursing mothers were allowed 3 eggs per week, children 1 egg per allocation. In March 1943 a priority at the rate of 3 eggs per week was given for infants between 6 and 18 months old. Such priorities were physiologically well founded and the deprivation of other groups occasioned thereby was offset by the allowance of 1 packet of dried egg powder, equivalent to 12 eggs, per allocation for every customer registered for shell eggs. During 1941–42 there was a very definite and continued fall in the production of shell eggs and concomitantly dried egg powder reached its highest point of consumption in the winter of 1943–44. Despite much propaganda, it was not a popular substitute for the shell egg. This was shown by the rapid increase in the "take-up" of shell eggs as soon as this became possible in the summer of 1945. Of course, this increased use of shell eggs was seasonal and during the winter months the public had perforce to make a greater use of dried egg powder. During the summer of 1945 there was a marked improvement in

the supply of shell eggs, an improvement the more striking when one considers the situation as it obtained in 1943–44 when the supply of shell eggs had fallen by 61 per cent of the pre-war figure. This tremendous fall in shell egg consumption was almost made good by the use of dried eggs which are nutritionally, but not entirely in the culinary sense, equivalent to shell eggs. On 22nd July 1945 the allocation of 3 shell eggs per week for children of 6 to 18 months was extended to children up to 2 years of age.

Dehydrated foods by loss of water suffer alteration of protein structure which will to some extent prevent on reconstitution the development of the full flavour, appearance and taste of the food. It is extremely difficult to get people to like a new type of food unless one is prepared to see to it that the new type of food can be well reconstituted, that a considerable period of time is taken over its introduction and that the public be fully instructed in the best methods for its use. That the Ministry of Food was fully alive to these points was demonstrated by their propaganda and the setting up of Food Advice Centres.

Butter and Margarine.—Before the war butter consumption in this country was 7·5 oz. per head per week. At the end of 1940 the consumption rate had fallen by 46 per cent and in 1944 by 70 per cent of the pre-war figure. This fall was entirely offset by an almost 100 per cent increase in the consumption of vitaminized margarine.

Meat.—In the pre-war period 1934–38 the amount of meat passing into civilian consumption in this country was 112·4 lb. per head per year; for the U.S.A. and Canada it was 111·7 and 97·3 lb. per head per year respectively. The fall in best quality meat and veal amounted in 1944 to 58 per cent of the pre-war figure. By the end of 1940 the United Kingdom total meat supply had fallen to 98·7 lb. per head per year, almost the Canadian pre-war figure—a 14 per cent reduction. By 1941 the reduction was 25 per cent and the consumption amount remained almost constant until 1944. The quality of the meat supplies suffered some deterioration, due to the stoppage of the importation of high quality chilled beef, the reduction in home production to conserve bread grain for human use, and the great increase in the import of frozen boneless beef. The amount of frozen meat coming into consumption rose rapidly

from 1·7 lb. per head per annum pre-war to 7 lb. per head per annum in 1941, to 15·6 lb. per head per annum in 1942, a 800 per cent increase, and for 1943–44 the consumption was 11·4 lb. per head per annum, a percentage increase over the pre-war consumption of 570. The marked fall in first quality beef coupled with a 25 per cent fall by 1941 in bacon and ham consumption was largely offset by an increase in canned beef consumption equal almost to that noted for frozen boneless meat (1942–43, 625 per cent). To secure as equitable a distribution of meat as possible, butcher meat was rationed from 11th March 1940 at 1s. 10d. worth per head per week. In September 1940 the price was raised to 2s. 2d. but fell to 1s. 10d. in December 1940 and to 1s. 2d. on 9th January 1941. From 31st March to 6th July 1941 the value was 1s. per head per week, but it was again raised to 1s. 2d. on 7th July 1941 and that level has been virtually maintained up to 1945. Children from 18 months to 5 years—that is, holders of Child's Ration Book RB2 had half a ration of meat, children 5 years and over were entitled to an adult ration of meat.

Numerous varieties of canned meats were on points rationing. Offals, meat pies and sausages, because of their perishability, were not rationed. The meat content of sausages was fixed at 37·5 per cent; some latitude in fulfilling this prescription was allowed. The nutritive value of sausages was improved when the addition of 7·5 per cent of low fat soya grits became compulsory on 25th July 1943.

Fish.—Fish, particularly fresh cheap fish, suffered a marked reduction in supply, due to the acquisition by the Admiralty of many trawlers for naval work. By 1940 the consumption of fresh fish fell by 45 per cent of pre-war intake, and remained at that figure until 1945. The consumption of canned fish remained almost at the pre-war figure throughout, with the single exception of the year 1940 when it was 44 per cent above the 1938 level.

Bread.—Extraction and dilution of wheat flour were the subjects for discussion in the first world war, extraction and fortification the bases of discussion in the second. In July 1940 the Accessory Food Factors Committee of the Lister Institute and the Medical Research Council recommended that extraction should be 85 per cent, on the knowledge that flour of high extraction contained appreciably greater quantities of

iron and vitamins of the B group than white flour. Acting on this advice, the Ministry of Food placed on the market the National Wheatmeal Loaf. This was in the spring of 1941, and during this year the national wheatmeal loaf was certainly not popular. This may have been due to its lack of palatability, poor keeping properties, uncertain colour, all of which may have been the result of allowing the bakers to make up an 85 per cent extraction by adding bran to white flour. In June 1942 the Medical Research Council advised that the bran content of the flour should be brought down from 6 to 4 per cent. This led to an improvement in colour and baking quality. Previous to April 1942 about 96 per cent of the people were eating white bread. Crawford in his book, *The People's Food for the Year* 1938, states that in the highest economic groups the ratio of white to brown bread was 3·7 to 1, while in the lowest groups it was 28·7 to 1. It was also noted that the highest economic groups reacted more favourably than the lowest to the national loaf, but after about one year it was still apparent that 50 per cent of the people continued to favour white bread and only about 25 per cent were wholly in favour of the new loaf. Several reasons were forthcoming for this unfavourable attitude; on the question of taste 50 per cent of consumers still continued to favour white bread, about 30 per cent accepted it, the remainder were doubtful or uninterested. As to its nutritive value, again about half of the people realized that the national wheatmeal loaf was better than white bread. Not a few complaints referred to the lack of those cutting and keeping properties which characterize white bread. The national loaf was an experiment, the lessons of which are only now (1945) being fully learnt. Millers after 3 or 4 months' experience in the production of 82½ per cent extraction flour can now produce an 80 per cent extraction flour, the nutrient percentage of which equals that of the 82½ per cent flour. In March, 1946, extraction was raised to 85 per cent.

Fruits.—Supplies of fresh citrus fruits fell very rapidly in 1941 until in 1943, 92 per cent of all fresh citrus fruits had disappeared from British homes. Oranges, whenever available, were subjected to a strictly controlled distribution, expectant mothers and children under 5 years of age having priority, the sale being limited to these groups for the first five days following the appearance of the oranges on the open market.

The consumption of citrus juices had, by 1943, been doubled, largely by the issue of them to infants and expectant mothers. Fresh tomatoes were maintained in good supply throughout.

In this brief account of the feeding of a nation in war-time no reference has been made to the difficult task of maintaining a steady flow of foodstuffs to the Navy, Army and Air Force in all parts of the world, but it will be readily realized that the feeding of the people of the United Kingdom was but one aspect of the whole gigantic problem facing the Government.

In Table 3A is given a summary of the changes in the consumption of the principal foods; the rates of consumption from 1938 to 1944 are given and the changes from 1938 to 1944 stated as a percentage of the 1938 figures. A detailed comparative statement of the consumption of foods in the U.S.A., Canada and United Kingdom throughout the period of the war has been published in *Food Consumption Levels*, 1944, issued by H.M. Stationery Office.

From the data in Table 3A the average number of Calories and the average amount of nutrients per head per week made available to the people have been computed and are shown in Table 3B. These figures represent in general terms the amount of food passing into civilian consumption and give no clue to the extent to which the available foods were taken up by different sections of the population. This latter point can only be decided, and that only approximately, by repeated dietary surveys. Table 3C made up from dietary and budgetary survey data, shows how varied can be the intake of nutrients despite controlled distribution of essential foods, and indicates, as these surveys always do, how important in the feeding of families is the amount of the net income (i.e. income available after rent and taxes have been deducted from the total weekly earnings). Table 3C shows quite clearly how impossible it is to obtain an adequate diet where the income is less than 10s. per head per week.

The dietary intake of the nutrients per head per week of the population did not in all respects fulfil the physiological requirements. It is to be remembered that by a more equal distribution of foods to all classes of the community and with the intakes mentioned, the people of the United Kingdom maintained a remarkably good health record during five years of total war. It will be admitted, without question, that in

peace time the full dietary requirements should be attained by all, but the standards generally referred to in the past have possibly been a little too high. During the war Calories have been on an average some 10 per cent below the normal, total protein has, on the other hand, been well maintained for adults in all but the lowest income groups, but not for adolescents.

Calcium.—In all low income groups, that is where the family income was less than 10s. per head per week, there was a very

Table 3a

A. A SUMMARY OF CIVILIAN CONSUMPTION OF THE PRINCIPAL FOODS PER HEAD PER WEEK FROM 1938 TO 1944

Compiled from data in *Food Consumption Levels*, H.M.S.O., 1944, and *Statistics Relating to the War Effort of the United Kingdom*, H.M.S.O., 1944.

This includes foods used in catering establishments and quantities used for food manufacture and also food produced by the people for their own consumption. This explains those figures which are higher than the domestic ration.

Food		1934–38	1940	1941	1942	1943	1944	1944 (Figure as a Percentage of the Pre-war Figure).
Milk, fresh	pints	3·30	3·45	3·94	4·22	4·32	4·49	
	per cent	100	106	121	130	134	136	136
Milk, dried	lb.	0·45	0·49	0·25	0·89	1·29	1·20	260
Cheese	oz.	2·71	2·52	2·55	4·34	3·83	3·51	130
Eggs, shell	no.	3·26	2·85	2·38	1·70	1·45	1·32	40
Eggs, dried	oz.	0·02	0·03	0·03	0·58	0·80	0·90	4500
Butter	,,	7·63	4·12	3·14	2·40	2·34	2·23	30
Margarine	,,	2·77	4·74	5·51	5·45	5·26	5·23	180
Beef, including veal	,,	17·12	14·08	11·20	7·40	7·18	7·18	42
Beef, boneless	,,	0·5	0·63	2·0	4·80	3·00	3·35	670
Bacon and ham	,,	8·4	6·18	5·88	6·00	5·78	5·89	70
Canned meat	,,	0·89	0·34	0·74	2·28	2·43	—	270
Total meats	,,	41·12	35·26	30·82	32·90	32·4	32·88	80
Fish, fresh and frozen	,,	6·52	3·66	3·72	4·25	4·56	4·56	70
Flour	,,	60·00	64·10	72·90	69·91	70·80	70·88	118
Total grains	,,	65·00	69·50	78·60	75·42	76·00	76·72	118
Citrus fruits, fresh	,,	8·70	6·35	1·30	1·56	0·69	0·78	9
Citrus fruits, including canned	,,	0·67	0·31	1·06	1·06	1·49	1·49	223
Tomatoes	,,	3·20	2·56	2·68	2·88	3·23	3·17	99
Potatoes	lb.	3·40	3·44	3·93	4·78	5·25	5·25	144
Sugar	oz.	30·58	20·22	18·52	19·45	20·00	21·40	70

TABLE 3B

B. NUTRIENTS AVAILABLE FOR CIVILIAN CONSUMPTION IN THE UNITED KINGDOM

From *Food Consumption Levels*, H.M.S.O., 1944.

		1938	1940	1941	1942	1943	1944
Calories . .	No.	2,984	2,772	2,795	2,864	2,827	2,854
Protein . .	g.	81	79	83	88	87	86
Fat . .	g.	129	118	111	117	123	114
Carbohydrates .	g.	373	347	364	364	366	371
Calcium . .	mg.	694	675	705	854	1,054	1,052
Vitamin A .	I.U.	3,868	3,320	3,634	3,857	3,882	3,932
Vitamin B_1 .	mg.	1·20	1·30	1·35	1·77	1·90	1·90
Vitamin C .	mg.	112	106	102	122	127	127

TABLE 3C

C. COMPOSITE TABLE OF DATA COMPILED FROM VARIOUS DIETARY AND BUDGETARY SURVEYS, SHOWING THE NUTRIENT CONTENT OF FOODS PURCHASED IN 3 INCOME GROUPS

		Average from all Sources per head per day	Income under 7s. per head per day	Income up to 10s. per head per day	Income up to 13s. per head per day
WINTER 1941–42					
Calories . . .		2,200 (92)	1,750 (78)	2,370 (98)	3,020 (118)
Proteins—					
Total . . .		71 (110)	55 (88)	77 (109)	102 (150)
Animal . . .		35	28	35	42
Calcium . . .		610 (67)	490 (54)	660 (74)	790 (88)
Vitamin A .	I.U.	2,600 (56)	1,900 (44)	2,900 (63)	4,000 (81)
Vitamin B_1 .	mg.	1·02 (73)	0.81 (60)	1·11 (77)	1·44 (94)
Vitamin C .	mg.	35 (50)	25 (37)	39 (56)	58 (80)
SUMMER 1942					
Calories . . .		2,300 (100)	1,880 (90)	2,350 (100)	2,930 (116)
Proteins—					
Total . . .		75	65	70	84
Animal . . .		33	24	30	37
Calcium . . .		740 (82)	580 (64)	740 (82)	930 (106)
Vitamin A .	I.U.	3,200 (70)	2,300 (50)	3,200 (70)	4,400 (120)
Vitamin B_1 .	mg.	1·14	0·90	1·29	1·65
Vitamin C .	mg.	95	65	100	130

Percentage of the requirements of the sample in brackets.

definite lack of calcium in the dietary. When one considers that milk is responsible for practically half of the calcium of the diet, a fall of 33 per cent in the intake is a serious matter. Consideration of the figures for calcium intake leads to the conclusion that priority supplies of milk to children and nursing mothers were fundamentally sound. Normal adults have a sufficiency of calcium stored in their bones to prevent the development of any untoward deficiency. Children and nursing mothers are in no such favourable position. These are nationally the most important categories and any criticism, and there has been some, of priority milk for these is based either on ignorance or prejudice.

Protein.—Throughout the 5 years from 1940–45 there was no essential change in the average amount of total protein ingested. Low income groups suffered up to 15 per cent deficiency: higher income groups suffered no deficiency. Animal protein was diminished on an average to 35 grams per head per day. Low income groups had less, probably as low as 25 grams per head per day. It is difficult to say to what extent the fall in total protein would have been detrimental to health, had the war lasted one or two years longer.

Vitamins.—In the lower income groups vitamins A and B have been reduced, on some occasions vitamin A being as low as 56 per cent of the required amount. The fall in vitamin A may at times have been due to a reduction in the consumption of liver. With regard to vitamin C, this has shown some serious deficiencies and only short seasonal increases above the normal. At the end of winter months or in the early spring, the amount of vitamin C in the dietaries of the people has been reduced for all groups and, on occasion, for the lowest income groups to 40 per cent of the requirement, but during the summer and late autumn with a greater consumption of green vegetables, there have been short periods of two to three months in which the intake was well above normal. Since vitamin C is not stored in the human body, any increase in the intake over short periods can be regarded as of little value in preventing scorbutic conditions when one considers the long winter periods in which the intake of this vitamin is so far below normal.

Vitamin C, always the least available of the vitamins, and particularly so at the end of a winter, showed as an average for low economic groups a 50 per cent fall in March

1942. The chief sources of vitamin C are vegetables supplying 48 per cent, potatoes 31 per cent and milk 11 per cent.

From a general survey of the food situation during the years 1943–44, one may conclude that a comparatively steady state of food consumption had been attained during these years. Having regard to the military disasters and reverses of 1940 and 1941 and the continued strenuous effort called for by all on the sea, in the air and on the land throughout the momentous year, 1942, one is surprised that, faced with unending difficulties of transport and distribution of food, the Ministry of Food was able to give the nation a diet so little removed from the normal in most of the required nutrients. From monthly surveys of the dietaries of the working classes—industrial and manual labourers—the constancy of the intake of foods is marked. Seasonal variations naturally occurred in the consumption of vegetables, preserves, milk in schools, and changes, due to oversea transport difficulties, become manifest in the alteration of food rations and "points" distribution. By means of the points system, introduced late in 1941, the purchase of non-rationed foods could be controlled as occasion arose. When a reduction in a main foodstuff became necessary, the loss of nutrients was made good by reducing the number of points required to purchase a foodstuff which was a good source of the principal nutrients diminished by the ration cut. The points system helped towards a better distribution of unrationed food. It controlled supplies by preventing any run upon an essential food, the equal distribution of which was a national necessity. That there was no increase in price in the foodstuffs on points made it possible that all economic groups could secure their fair share. Thus the highly paid workers were prevented from buying from more than one shop and thereby securing more than their share of essential foods.

Some criticism was levelled at restaurants in that those who could afford it could, without coupons, buy extra amounts of meat and other foodstuffs, which were on the ration, but Major Lloyd George, in a statement made in the House of Commons, pointed out that there would be considerable difficulty in collecting ration coupons in various restaurants, canteens and eating places and, as a large proportion of the people in large cities fed at midday in restaurants, it was necessary to preserve a certain elasticity. That some meat went to those who did

not require it, to the detriment of the physiological needs of others, may be quite true, but none would deny the value of the British Restaurants and catering establishments in supplying supplementary rations to men and women engaged in war work.

The nutritional improvement which was evident in 1944 could be laid down to the increased extraction rate of flour, an 85 per cent extraction enhancing markedly the nutritive properties of bread ; to an increased intake of milk, so markedly increased that supplies were at times strictly limited and the adult ration of milk seriously reduced. That any improvement in the general health of the people could have taken place when eggs, bacon, fish, sugar, preserves and fruit were all greatly reduced is as surprising as it was satisfactory. The surprise perhaps is not so great when one realizes that the solution of the problem of the feeding of a nation depends upon an efficient distribution of essential foods and a minimum wage consonant with a required standard of living. In spite of difficulties, mistakes and disappointments, credit is certainly due to all who helped to make this experiment in national feeding the success it has proved to be.

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CHAPTER V

THE ENERGY REQUIREMENTS OF THE BODY

THE body requires energy because it has to grow, to create heat, to make good wear and tear and to do work.

All energy is expressed as heat or work, and in the human body it is derived from the oxidation of carbon, hydrogen, nitrogen, sulphur and other elements of which the foodstuffs are composed. The foodstuffs cannot be used directly as sources of energy but are reduced by the processes of digestion to certain soluble forms which permit of their easy transference across the wall of the intestine into the blood. In the processes of digestion, work is performed in the alimentary tract, and the amount of work done will depend on the nature of the foods to be digested. Some of the soluble substances will be reconstituted in the various parts of the body to form muscle, bone, nerve and other tissues ; some will be utilized to supply the energy for the rebuilding and maintenance of the tissues. If after a period of twelve hours when no food has been taken and therefore no absorption is taking place, the amount of energy expended by the body be measured, an exact record is obtained of the irreducible minimum of energy necessary to keep the body alive, that is, to maintain its temperature, the action of the heart, the movements of respiration and the resting activity of glands (liver, kidneys, thyroid, pituitary, etc.). This is known as the basal metabolic rate, or the B.M.R. When work is performed outside the body, it varies greatly, forming from one-third to three-fourths of the total energy output of the body.

The great variations in external energy production depend upon the general activity and the occupation of the individual, and such variations are in marked contrast to the constancy of the basal metabolism. This means that the greater the amount of muscular work done the greater must be the amount of food consumed.

Heat is produced in the resting body by the oxidation of foodstuffs and by the tonic activity of the musculature of the

body. In the event of work being carried out, a greater amount of heat will be produced. In this respect the body is essentially a machine. A locomotive has a thermal efficiency of 10 per cent, an internal combustion engine 20 per cent, a Diesel engine about 40 per cent. The human body varies in its efficiency according to the conditions under which work is performed. Much depends upon training, the type of work, adaptability to the task, the onset of fatigue, etc. The average efficiency of the human machine may be taken as 20 per cent; the maximum is probably not over 35 per cent: that is to say, of the total oxygen burned, 35 per cent is burned to produce work; the remaining 65 per cent is burned to produce heat. The body, like an engine, obeys the law of the conservation of energy, which states that no energy is ever created or destroyed. Therefore the total output of energy by the body is the sum total of the energy derived from the fuel stores within the body and from food ingested. But the analogy between the body and an engine must not be pushed too far, for there are essential differences, the most important of which are that the body never stops working, that the oxidations within the muscle take place during recovery following contraction, that any depletion of fuel is immediately made good and that fuel material is used for tissue repair.

The Determination of Energy or Fuel Values.—The instrument which is used to determine how much energy is produced by the combustion of any substance in oxygen is called a calorimeter, i.e. a heat measurer. It is a closed chamber, insulated to prevent the loss of heat to the exterior. Into it is placed an accurately weighed amount of the substance to be burned, the calorimeter is filled with oxygen and the substance is burned by electrical ignition. The heat produced is accurately measured in degrees Centigrade, and the relation, heat produced per gram of substance burned is stated in Calories. In experiments upon foodstuffs the large Calorie is used, and its definition is:

"A large Calorie (always written with a capital C) is the amount of heat required to raise 1000 grams of water from 15° C. to 16° C." Grams and degrees Centigrade may appear at first a little strange to some, but these are the scientific terms used, and they are, of course, within the metric system. It is well

to be able to convert grams to ounces and degrees Centigrade to degrees Fahrenheit.

$$1 \text{ oz.} = 28{\cdot}5 \text{ grams.}$$
$$°C = (°F - 32) \times 5/9.$$
$$°F = (9/5 \times °C) + 32.$$

It should be noted that in the oxycalorimeter (Fig. 1), since no work is done, all the energy is expressed as heat. Now, in the body at rest, when no external work is done, one can measure the heat produced and so determine the minimal or basal energy output of the body. To do this, the subject of the experiment is put in a closed chamber, but he is not ignited and burned in oxygen, he is simply allowed to lie comfortably in the insulated chamber, and the amount of heat produced is accurately measured. This is a purely scientific method and requires years of training and experience to carry it out correctly. In the examination of the energy output or basal metabolism of patients in hospitals, such a method would be impracticable, and fortunately it is possible to arrive at very accurate results by indirect methods. This is called " indirect calorimetry ", and all that it entails is the accurate estimation of the oxygen used by the subject over short intervals of six, ten or fifteen minutes. It will now be apparent that there is a relation between heat produced and oxygen used, be it in the burning of a foodstuff in a calorimeter or proteins, fats and carbohydrates in the human body. This relation of heat or energy to oxygen used is called the calorific value of oxygen. While the calorific value of oxygen varies slightly for different types of foodstuffs burned by the body, we may take it at present that one litre of oxygen has a calorific value of 4·8 Calories. One must become used to these terms, particularly the term Calorie, because foods as bought vary greatly in their energy, i.e. calorific or fuel values. It is only by such terms that one can express quantitatively the fuel values of foodstuffs ; without these terms no accurate comparisons can be made, for some foods are concentrated fuels requiring but small amounts to be used ; others are of little energy-producing value because they are made up largely of water, cellulose, and salts and have but small amounts of protein, carbohydrate or fat.

The conditions which determine energy needs are the amount of active tissue in the body, the intensity of the activity

FIG. 2. The Roth-Benedict apparatus.

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within these tissues and the work done by the body in promoting growth, maintaining repair and in meeting all the demands made upon its musculature in the routine tasks of everyday life. There are other and special conditions which add to the energy requirements of the body; they are pregnancy and lactation, convalescence from infectious disease and the treatment of endocrine deficiency disease. The active tissues of the body are the muscles and all glands. Structures such as bones, arteries and nerves have a very limited metabolism compared with the glandular tissues. The muscles, the liver, the salivary, gastric and intestinal glands and the endocrine organs are the seat of chemical processes by which energy is transformed from the food into heat and work. And not only into that work which is apparent and can be accounted for, but into those invisible activities whereby digestive juices are formed for dealing with ingested food, external secretions are elaborated for controlling assimilation and utilization of the products of digestion and internal secretions are produced for the regulation of all those chemical changes upon the correct interrelation of which the health and well-being of the body depends.

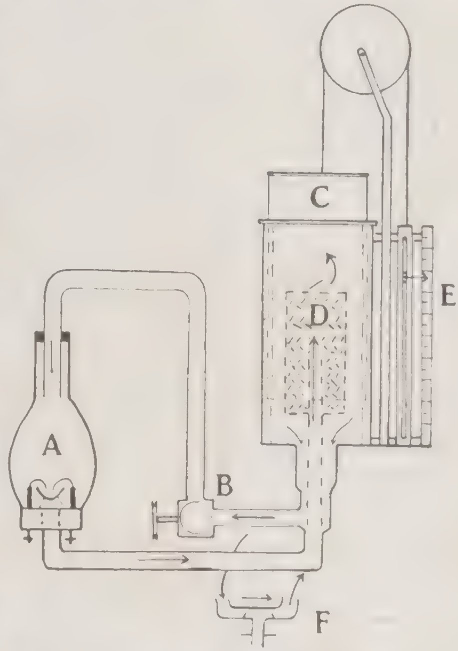


Fig. 1.—Diagram of oxycalorimeter for determining energy values of foods, etc.

(A) Combustion chamber for nickel crucible and electrical connections. (B) Rotary blower. (C) Spirometer bell with oxygen in water seal. (D) Soda lime container. (E) Scale in millimeters for measuring the oxygen used. (F) Mouth-piece with valves for B.M.R. estimation (enlarged).

Principle of the Roth-Benedict apparatus for determining B.M.R. is seen by replacing A and B by F.

Estimation of the Basal Metabolic Rate.—The principle of the Benedict-Roth apparatus for the estimation of basal metabolism is shown in Fig. 1. The apparatus as used experimentally is shown in Fig. 2. The individual breathes pure

oxygen and all exhaled carbon dioxide (CO_2) is absorbed by soda lime. The oxygen used is indicated by the fall in the spirometer bell, which is calibrated so that the amount of oxygen removed per millimetre drop in the bell is known. Thus from the fall in the oxygen line over a period of six minutes, see Fig. 3, one can calculate the energy expended in terms of Calories per square metre of body surface per hour. In charts supplied for the calculation of the B.M.R. the oxygen line in millimetres is equal to Calories per square metre per hour. For this rapid method of estimation the calorific value of oxygen is taken as 4·825 Calories per litre and the spirometer bell is made with a diameter of 16·5 cm. and therefore a factor of 20·73 c.c. per mm. This gives 1 mm. $= 20{\cdot}73 \times 4{\cdot}825 = 0{\cdot}100$ Calories: if for a period of 6 minutes the O_2 line shows a fall of 80 mm. then $80 \times 0{\cdot}1 \times 10 = 80$ Calories per hour. To estimate the body surface of the subject one uses the standard formula of Du Bois: $S = W^{0{\cdot}425} \times H^{0{\cdot}725} \times C$ or $\log S = (\log W \times 0{\cdot}425) + (\log H \times 0{\cdot}725) + \bar{3}{\cdot}8564$.

S = Surface in square metres.
W = Weight in kilograms.
H = Height in centimetres.
C = A constant = 0·007184.

More conveniently the area is obtained by the use of a nomogram such as is shown in Fig. 4 or from Table 4. The basal metabolic rate is always stated as a percentage of the normal for an individual of the age and surface area of the subject examined. As an example: it is known that for an adult man 25 years of age, the B.M.R. is 40 Calories per square metre per hour.

Weight = 70 kg. or 154 lb.
Height = 170 cm. or 68 inches.
Surface area = 1·8 square metres.
The O_2 line or Calories per hour = 96 mm.
Correction factor for normal temperature and pressure = 0·8.
The B.M.R. = 96 × 0·8 = 76·8.

The normal for a person 25 years of age, having a surface area of 1·8 sq. m. is 40 × 1·8 = 72.

The B.M.R. of the subject expressed as a percentage of the normal (72) = + 6·66.

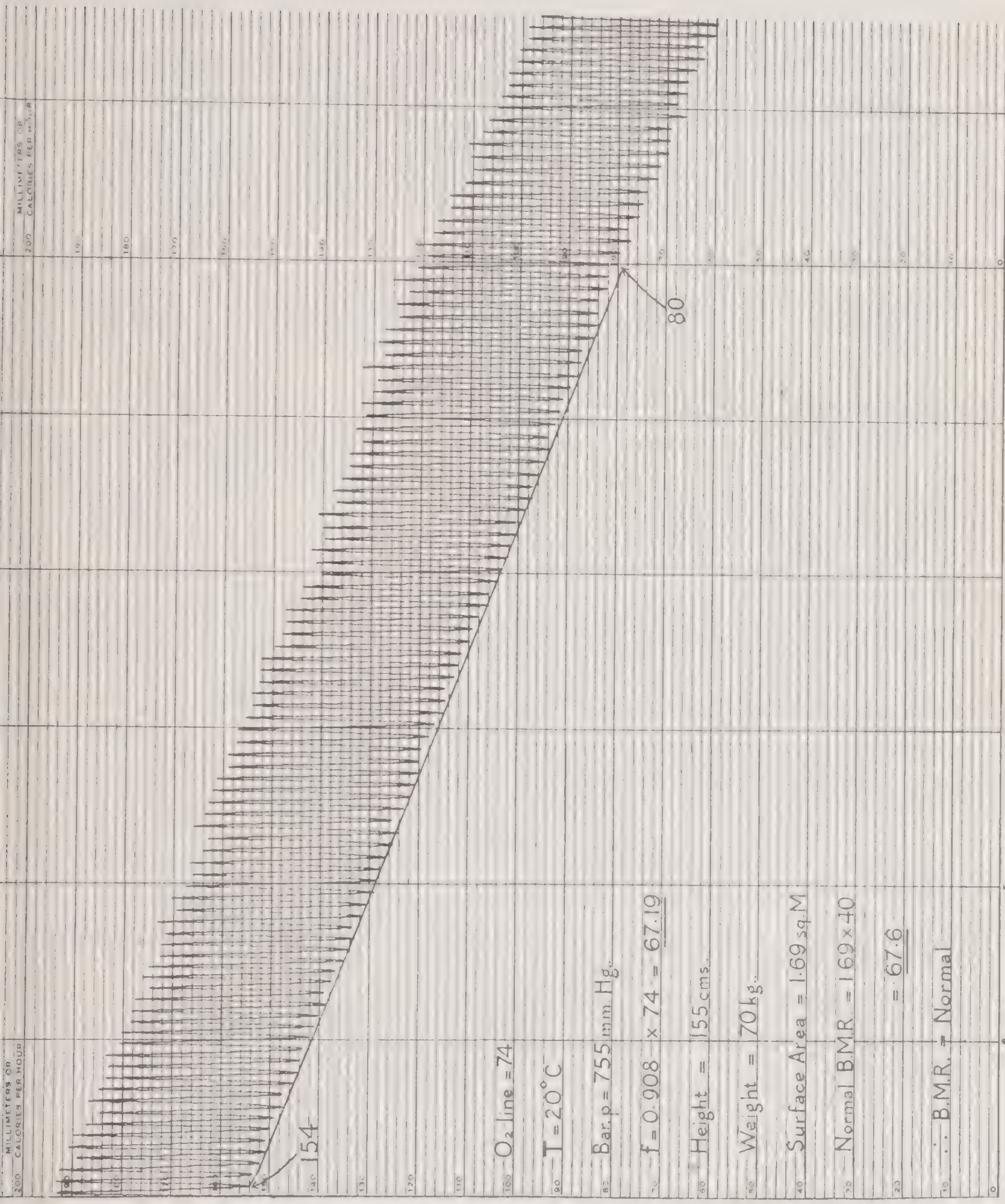
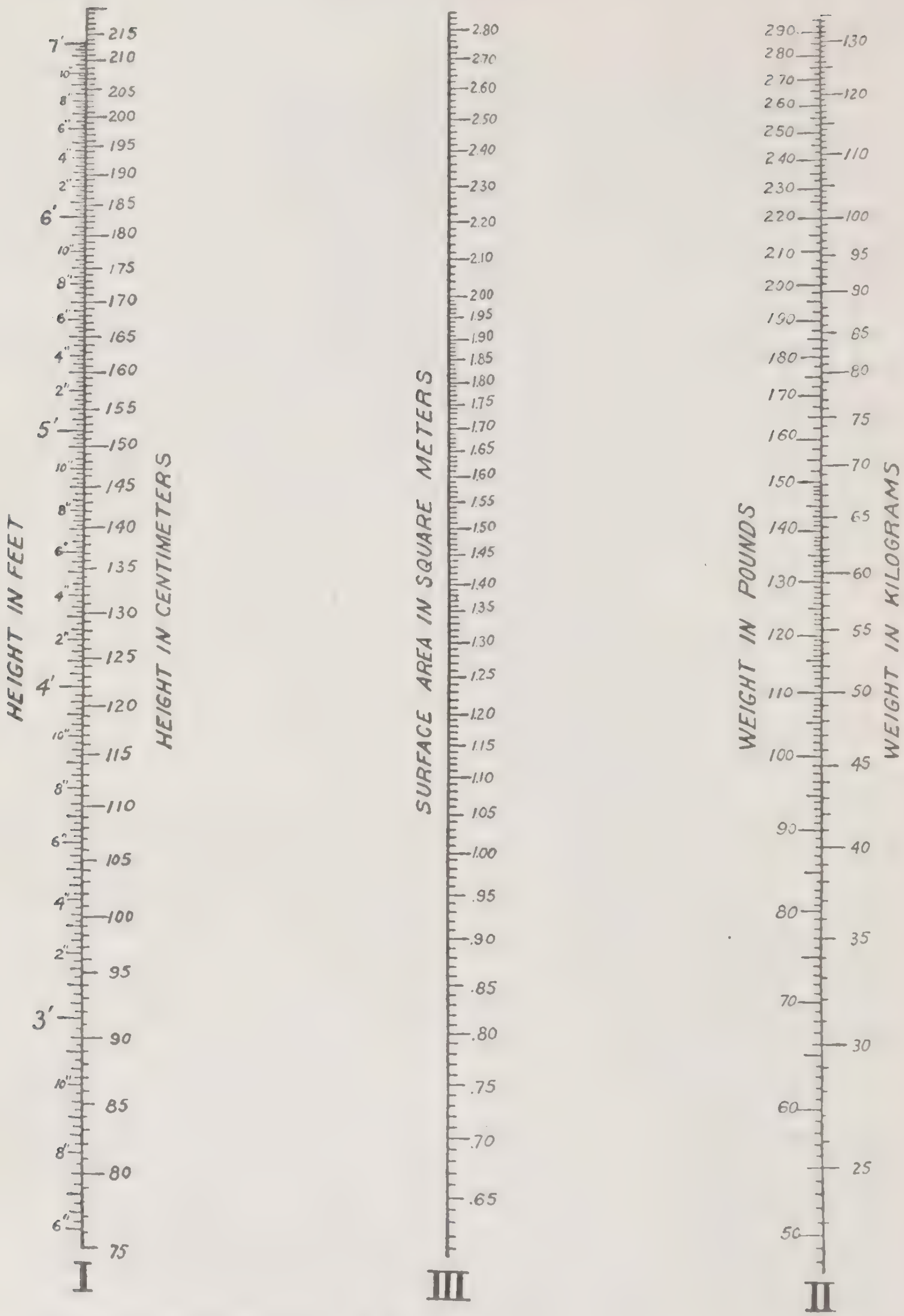


Fig. 3.—Chart of oxygen line and data for the estimation of the B.M.R.



Draw a straight line through the appropriate points on columns I (Height), and II (Weight). Read the Surface Area where the line intersects column III.

Fig. 4.—Du Bois chart for computing surface area of the body from height and weight as prepared by Boothby and Sandiford of the Mayo Clinic.

Table 5 gives the height, weight and surface area of males and females from 1 to 25 years of age.

The Basal Metabolic Rate and Total Energy Requirements of Children and Adolescents.—In the new-born child the basal metabolic rate is low, approximately 25 Calories per square metre per hour, but it rises quickly until at six months it is about 43 and at twelve months 47 Calories per square metre per hour. The maximal rate, 48 to 50 Calories per square metre per hour, is reached in the second year (see Table 6). The high rate in infancy is due to the rapid growth of the infant, particularly in respect of the growth of muscle and the development of muscle tone. It is the period of change from the helpless, muscularly inactive infant to the would-be helpful, intensely active and alert child. It is a period of growth in which the central nervous system is keeping pace with a rapidly increasing musculature, a period in which the finer interrelation of brain tissue with muscle activity is fully developed and is evidenced by the development of postural

Table 4

SURFACE AREA IN SQUARE METRES FOR DIFFERENT HEIGHTS AND WEIGHTS

Weight in Kilograms

Height cm.	25	30	35	40	45	50	55	60	65	70	75	80	85	90
200								1·91	1·97	2·03	2·09	2·15	2·21	2·26
195							1·80	1·87	1·93	1·99	2·05	2·11	2·17	2·22
190						1·70	1·77	1·84	1·90	1·96	2·02	2·08	2·13	2·18
185					1·60	1·67	1·74	1·80	1·86	1·92	1·98	2·04	2·09	2·14
180				1·49	1·57	1·64	1·71	1·77	1·83	1·89	1·95	2·00	2·05	2·10
175			1·36	1·46	1·53	1·60	1·67	1·73	1·79	1·85	1·91	1·96	2·01	2·06
170		1·26	1·34	1·43	1·50	1·57	1·63	1·69	1·75	1·81	1·86	1·91	1·96	2·01
165	1·14	1·23	1·31	1·40	1·47	1·54	1·60	1·66	1·72	1·78	1·83	1·88	1·93	1·98
160	1·12	1·21	1·29	1·37	1·44	1·50	1·56	1·62	1·68	1·73	1·78	1·83	1·88	1·93
155	1·09	1·18	1·26	1·33	1·40	1·46	1·52	1·58	1·64	1·69	1·74	1·79	1·84	1·89
150	1·06	1·15	1·23	1·30	1·36	1·42	1·48	1·54	1·60	1·65	1·70	1·75	1·80	
145	1·03	1·12	1·20	1·27	1·33	1·39	1·45	1·51	1·56	1·61	1·66	1·71		
140	1·00	1·09	1·17	1·24	1·30	1·36	1·42	1·47	1·52	1·57				
135	0·97	1·06	1·14	1·20	1·26	1·32	1·38	1·43	1·48					
130	0·95	1·04	1·11	1·17	1·23	1·29	1·35	1·40						
125	0·93	1·01	1·08	1·14	1·20	1·26	1·31	1·36						
120	0·91	0·98	1·04	1·10	1·16	1·22	1·27							

tone, balancing mechanisms and numerous physiological adaptations. There is then a steady falling off in the intensity of metabolism up to the fifth year, and a slower decline through later childhood, followed by a slight increase in activity as puberty is reached. Metabolic activity is then continued with a slow steady deceleration throughout the period of adolescence. While in adults all that is necessary is to maintain a normal weight by an intake of food, the energy value of which balances

TABLE 5

HEIGHT, WEIGHT AND SURFACE AREA OF CHILDREN AND ADOLESCENTS

	Males					Females				
Age years	Height		Weight		Surface Area in sq. metres	Height		Weight		Surface Area in sq. metres
	in.	cm.	lb.	kg.		in.	cm.	lb.	kg.	
1	29	72	22	10	0·50	29	72	20	9	0·48
2	32	82	27	12	0·55	33	82	26	12	0·55
3	37	92	31	14	0·63	37	92	31	14	0·63
5	41	102	41	18	0·71	41	102	40	18	0·70
8	48	120	53	24	0·88	48	120	50	23	0·83
11	53	133	70	32	1·10	53	133	69	32	1·10
12	55	137	77	35	1·15	56	140	78	36	1·20
13	57	142	85	39	1·24	58	145	89	41	1·28
14	60	150	95	43	1·33	60	150	98	45	1·36
15	62	155	108	49	1·45	62	155	106	48	1·43
16	65	162	121	55	1·57	63	157	112	51	1·49
18	67	167	132	60	1·66	64	160	123	56	1·57
20	68	170	140	64	1·74	65	162	127	58	1·59
25	68	170	154	70	1·80	65	162	130	59	1·60

the energy requirements of the body, in children the question of growth must receive careful attention. Growth, in normal children, is always associated with great muscular activity, and the intake of food must be increased in order that it may adequately balance basal metabolism, muscular activity and growth. A rapidly growing child may utilize up to 15 per cent of the energy value of its food for growth alone. This is the extra energy which is utilized to build up new tissue. In childhood and adolescence variations in the basal metabolic rate of 10 to 15 per cent are quite normal. From the results

of numerous investigations Table 7 has been constructed: it shows the general average for the height in inches and centimetres, the weight in pounds and kilograms, and the surface area in square metres, the daily basal metabolic and total energy requirements in Calories for ages 1 to 25 years. These last figures, which are the recommended daily amounts published by the National Research Council, Washington, U.S.A. (1941), represent energy requirements in Calories for

TABLE 6

A COMPARISON OF METABOLIC RATES OF MALES AND FEMALES

	B.M.R. per sq. metre per hour		Basal Calories per sq. metre per 24 hours		Total Basal Calories per 24 hours	
	Males	*Females*	*Males*	*Females*	*Males*	*Females*
Birth . . .	25·0	25·0	600	600	230	230
1 year . .	47·5	46·2	1140	1108	570	554
2 years . .	48	45·5	1152	1092	635	600
3 ,, . .	47	43·2	1128	1037	711	653
5 ,, . .	44·5	41·5	1068	996	761	697
8 ,, . .	42·0	40·0	1008	960	887	797
11 ,, . .	39	38–41	936	912	1029	1003
12 ,, . .	39–50	38–42	936	912	1076	1094
13 ,, . .	39–46	38–41	936	912	1161	1177
14 ,, . .	40–44	38–41	960	912	1276	1240
15 . . .	41–44	35–40	984	840	1427	1201
16 ,, . .	41–43	34–40	984	816	1545	1216
17 ,, . .	41 ·43	33–39	984	792	1574	1225
18 ,, . .	41–43	32–38	984	768	1633	1205
20 ,, . .	40–42	31–35	960	744	1670	1182
25 ,, . .	39–41	31–33	936	744	1684	1190
40 ,, . .	38	30	—	—	—	—
60 ,, . .	36	30	—	—	—	—

normal or moderate activity. The most important fact indicated by this Table is the great increase in the basal metabolic needs of children between the ages of 8 and 16 years.

The facts so far presented are graphically represented in Fig. 5. The growth curves for boys and girls show a divergence first at about 10 years of age when girls on an average grow a little more rapidly than boys with the result that, at about 13 years of age, girls are about 3 to 4 lb. heavier and may even be taller than boys of that age. Interesting at this latter age is the marked change in the total expenditure of energy between

boys and girls. Boys from 14 years onwards continue to increase their total metabolism, girls, on the other hand, remain almost at a constant figure. In this connection one should also note the basal metabolic rate given in Calories per day for both sexes. From a high level at 2 years, both sexes steadily

TABLE 7

TABLE RELATING HEIGHT, WEIGHT AND SURFACE AREA TO THE DAILY BASAL METABOLIC RATE AND TOTAL ENERGY REQUIREMENTS

Age years		Height in.	Height cm.	Weight lb.	Weight kg	Surface Area sq. metres	Total Basal Metabolism in Calories per day	Total Calories per day (U.S.A.)	B.M.R. as a % of the total Calories
1		29	72	22	10	0·50	570	900	63
2		32	85	27	12	0·55	635	1200	53
3		37	92	31	14	0·63	711	1400	44
5		41	102	41	18	0·71	761	1600	47
8		48	120	53	24	0·88	887	2000	44
11		53	133	70	32	1·10	1029	2500	41
14	boys	60	150	95	43	1·33	1276	3200	40
	girls	60	150	98	45	1·36	1240	2800	51
16	boys	64	160	118	54	1·57	1545	3500	44
	girls	62	155	110	50	1·49	1216	2600	46
18	boys	67	167	132	60	1·57	1633	3800	43
	girls	63	157	112	51	1·49	1205	2400	50
20		68	170	140	64	1·74	1670	3800	44
25		68	170	154	70	1·80	1684	3500	48
Man—sedentary. 65 kg. = 143 lb.								2500	
moderately active								3000	
very active								4200	
Woman—sedentary. 58 kg. = 127 lb.								2100	
moderately active								2500	
very active								3200	
Pregnancy (latter half)								2500	
Lactation								3000	

fall to the age of the onset of puberty when, after a period of constant metabolism, boys—age 14 years—increase their metabolism, while that of girls slowly falls to the average for the adult woman. The factor at play, and it may by no means be the only factor, is the relation between the rate and extent of growth of the body and its changing surface area.

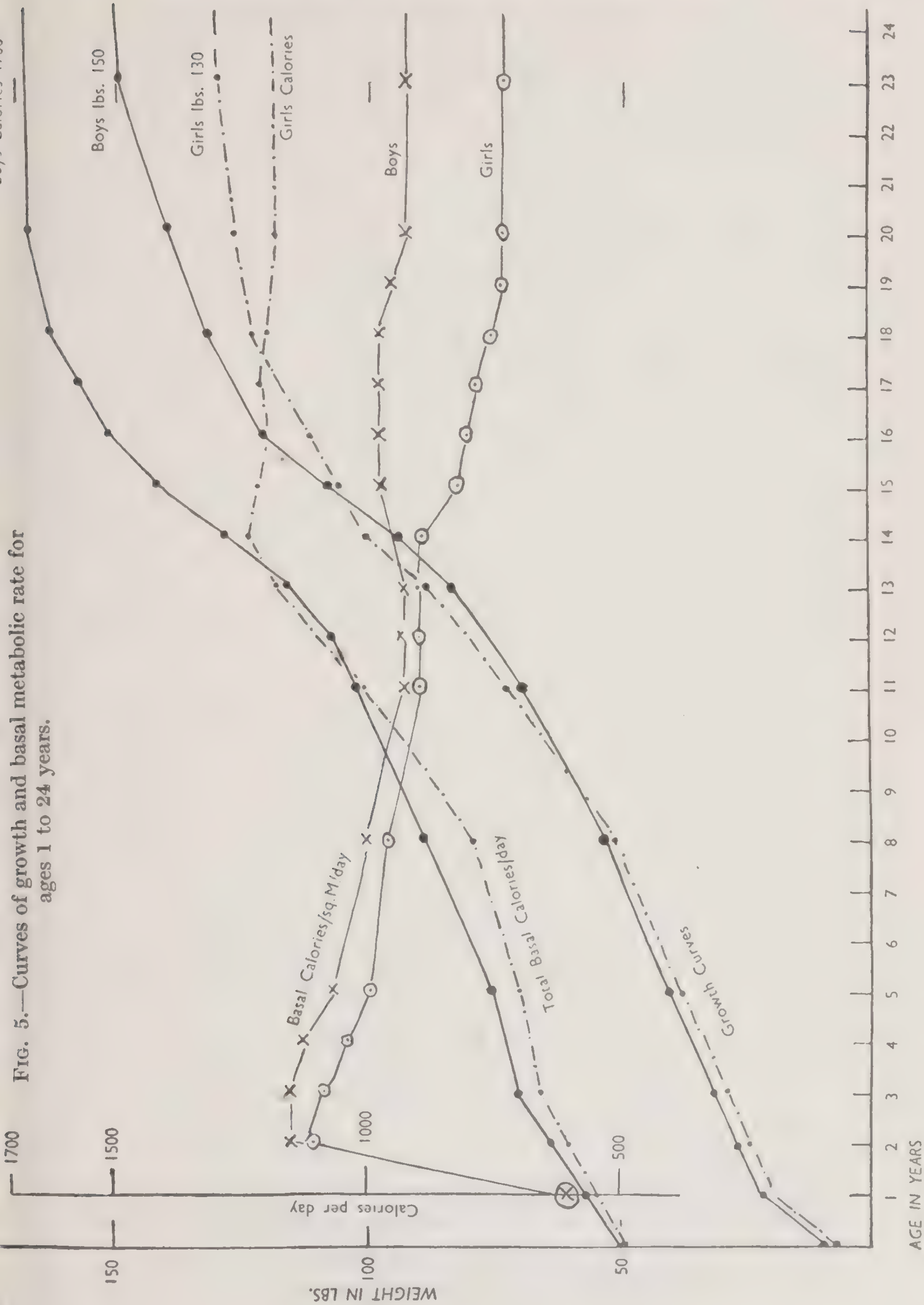


FIG. 5.—Curves of growth and basal metabolic rate for ages 1 to 24 years.

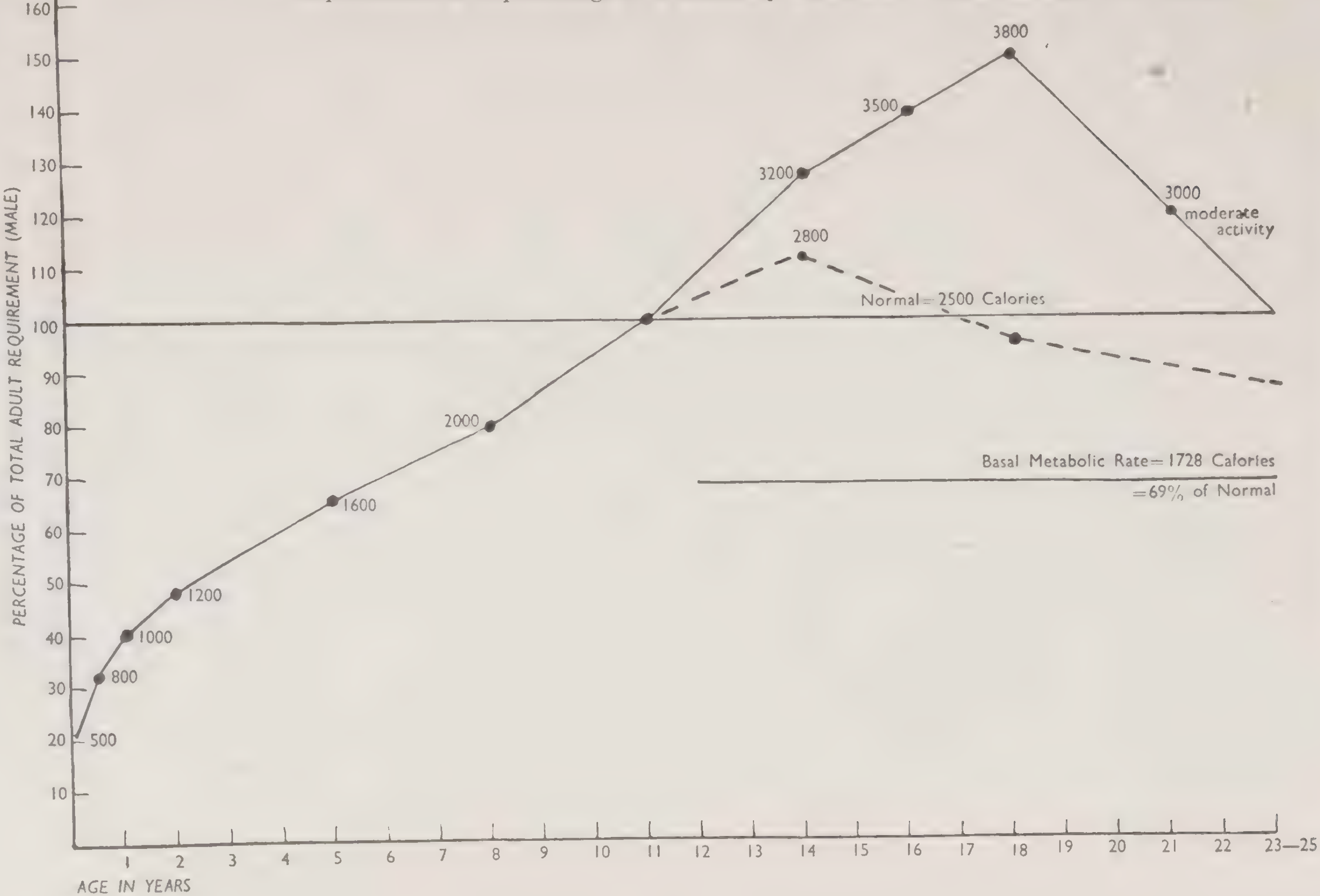
If one considers the matter further and compares the energy requirements of boys and girls in relation to those of their fathers and mothers respectively, assuming naturally that the parents are normal and are at leisure, one is impressed by the needs of adolescents.

In Fig. 6 the energy requirements of children and adolescents are shown as a percentage of the normal sedentary parent. The upper curve shows clearly how the energy needs of the boy between 11 and 18 years exceed those of his father. At 11 years they are equal, at 14 years they are 28 per cent greater and at 18 years 52 per cent greater than the adult male with a normal energy output of 2500 Calories. The dotted line in this chart shows the adolescent girl's requirements as a percentage of those of her father. In Fig. 7, however, the adolescent girl is compared with her mother, whose sedentary energy output is 2100 Calories. One important fact emerges, namely, that from 9 years of age until probably 20 years, the daughter has a calorific need which, when she is 9 years old, is equal to that of her mother, and when 14 years old, is 33 per cent greater. It then falls steadily until at about 20 to 25 years of age her leisure requirements are again equal to those of her mother.

The question may arise as to how these Calorie requirements are determined, in view of the fact that they are associated with great and varying outputs of activity.

Numerous studies have been made of the increase over basal metabolism occasioned by different forms of exercise. Many of these investigations have been carried out by the method of indirect calorimetry, in which oxygen is inhaled from a Douglas bag carried by the subject and the CO_2 produced is absorbed by soda lime in metal containers through which the expired air passes. These are carried by the subject with the bag, if a race is being run, or placed with the bag by his side if stationary exercise is carried out. Such an experiment will give a figure for oxygen utilization from which the increased metabolism for the time of the exercise can be calculated. From such experiments are obtained figures which show, for the period of the exercise, the effect which swimming, dancing or rowing, etc., etc., has in increasing metabolism. Now for children and adolescents, whose activities are too varied to be correctly tabulated and accurately measured, there is only one

sedentary requirements of a man. Weight = 70 kg. (154 lb.); Height = 170 cm. (5 ft. 8 ins.); Surface area = 1·80 square metres. The dotted line shows a girl's calorific requirements as a percentage of a sedentary adult man. Note the ages 11–17 years.



method which, if carried out over sufficiently long periods, gives fairly accurate information as to the energy expenditure day by day and that is to measure periodically the actual food consumption day by day for a week. This method has been very fruitful in results. From a sample of all the meals taken each day, dried and burned in the oxycalorimeter or by a careful dietary survey, the calorific value of the food is determined. The weight and height of the child are accurately recorded at intervals during the period and if the growth curve is normal and the children dietetically satisfied, then it is accepted that the Calories taken as food have been sufficient to supply the energy requirements and maintain normal growth.

The Effect of Muscular Work on Metabolism.—It is known that in a resting condition with food, about 77 per cent of the body heat is lost by radiation and conduction, 21 per cent by evaporation of moisture from the skin and the lungs and 2 per cent by urine and fæces. When a measured amount of work is done, equal, as in the following Table, to 550 Calories, then the total energy expenditure rises to 5130 Calories, the percentage dissipation of which by radiation and conduction is 74, by urine and fæces 0·6, by the evaporation of moisture from the skin and lungs 14·7, as work 10·7. The excess metabolism over the resting metabolism with food is 5130 − 2400 = 2730 : this represents the metabolism which must take place in order that the body may perform work equal to 550 Calories.

HEAT LOST IN CALORIES BY

	Radiation and Conduction	Urine and Fæces	Evaporation, Lungs and Skin	Active Work	Total Calories
Resting with food . .	1850 (77%)	28 (2%)	522 (21%)	—	2400
Work with food	3800 (74%)	30 (0·6%)	750 (14·7%)	550 (10·7%)	5130

The mechanical efficiency of the body in doing this work is :—

$$\frac{\text{work}}{\text{excess metabolism}} = \frac{550}{2730} = 20 \text{ per cent.}$$

The Effect of Fever on Metabolism.—In a high environmental temperature, e.g. 100° F. in the shade, the humidity

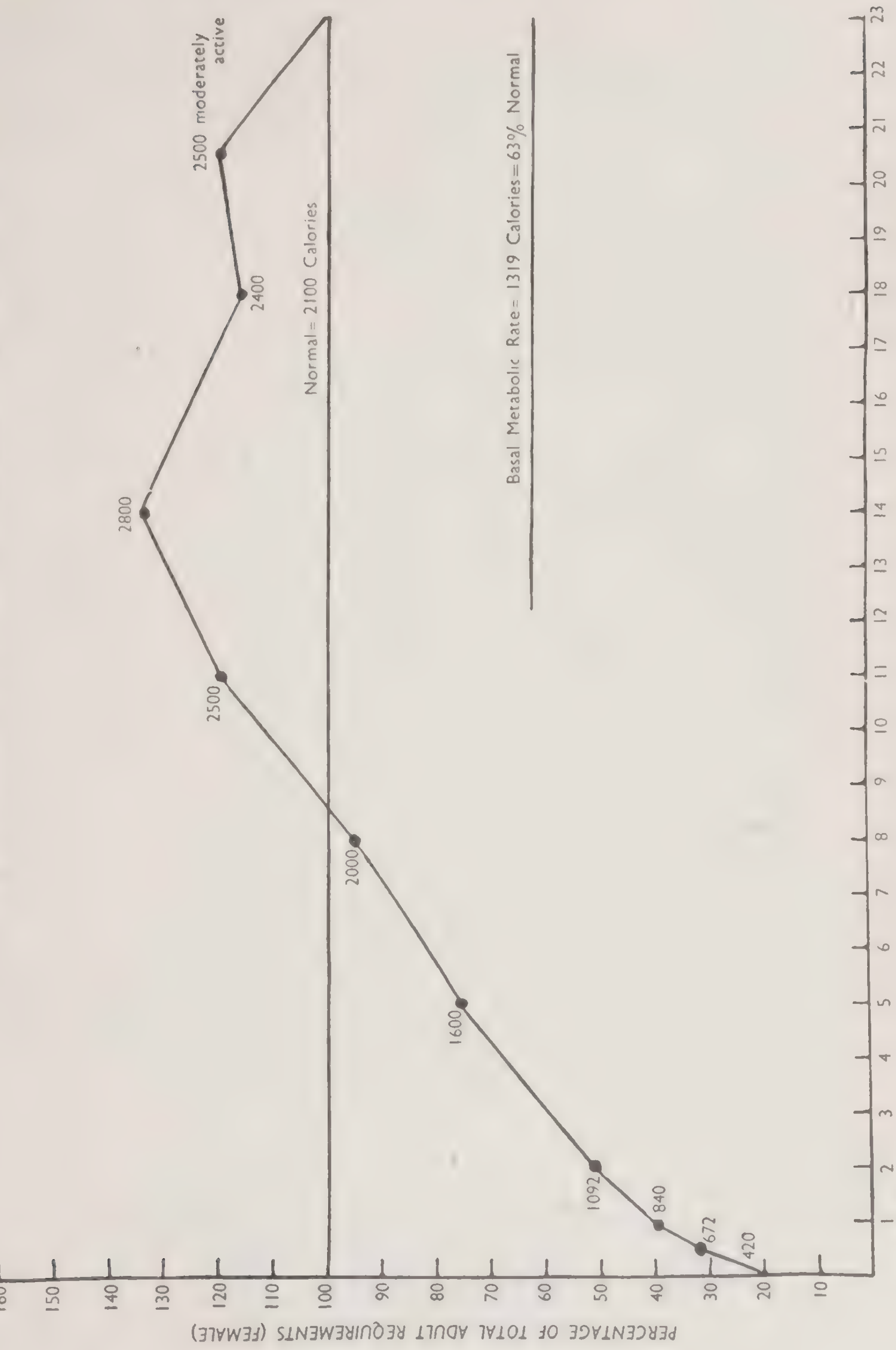


FIG. 7.—The total energy requirements of girls at various ages as a percentage of the sedentary requirements of a woman. Weight = 58 kg. (127 lb.) Height = 162 cm. (5 ft. 5 ins.); Surface area = 1·57 square metres.

of the air does not interfere markedly with perspiration and there will be practically no change in the body temperature. If, however, there be no loss of heat by evaporation of moisture from the skin or by radiation or conduction as in a very high relative humidity, e.g. 90 per cent, the body temperature will

Table 8

TABLE GIVING AN APPROXIMATE IDEA OF CALORIE VALUES

	Calories
Milk, one glass (8 oz.)	150
One tablespoonful of butter (0·5 oz.)	100
Cream, one tablespoonful (1 oz.)	60
Ice cream, $\frac{1}{4}$ cup	100
One egg	75
Cheese, 1-inch cube (1·0 oz.)	100
Meat, lean, 1 oz. (cooked)	70
Meat, average fatty, (1 oz.)	100
Liver (stewed), (1 oz.)	60
Bacon, slices, four average (156 Cals./oz.)	100
Sausages, two average sized	100
Fish, fatty, e.g. herring (2 oz.)	100
sardines (2 oz.) (canned)	160
Sugar, two tablespoonfuls (1 oz.)	100
Jam, syrup, honey, etc., 1 tablespoonful (1 oz.)	80
Rice (1 oz.)	100
Potatoes, one medium sized, boiled (4 oz.)	80
Cereals, $\frac{1}{2}$ cup (2 oz.) (e.g. oatmeal)	220
Oatcake (1 oz.)	100
One thick slice of bread (1·5 oz.)	100
One banana or orange, average size	75
One apple or pear, average size (approx. 4 oz.)	50
Dates, five medium size ($1\frac{1}{2}$ oz.)	100
Prunes ($1\frac{1}{2}$ oz. dried or $2\frac{1}{2}$ oz. cooked)	60
Raisins, $\frac{1}{4}$ cup ($1\frac{1}{3}$ oz.)	100
Orange or grape fruit juice, 1 cup	100
Figs, dried (1 oz.)	60
Chocolate, plain (1 oz.)	150

rise and with it an increase in oxygen utilization. For every degree Fahrenheit that the body temperature is raised there is a 7 per cent increase in basal metabolism which is equal to 120 Calories. It is always a problem for the physician to determine in febrile cases just how much of the extra expenditure of energy should be met by increased food. A judicious prescrib-

ing of diet must accompany very skilful nursing in all highly febrile cases.

Under conditions of lowered external temperature, the body conserves its heat by diminishing blood supply to the skin, reducing perspiration and by shivering, that is, by increasing the fine tonic contraction of muscles. It requires temperatures below 25° C. to produce any definite change in basal metabolism of a nude person. When the body temperature has fallen from the normal 37·5° C. or 98·6° F. to 15° C. or 59° F. shivering may be sufficient to double the basal metabolic rate.

The Effect of Pregnancy.—In pregnancy, while there is a gain in weight of the mother of 15 to 20 lb., representing the weight of the child, placenta, water and membranes, the maternal basal metabolic rate is not increased beyond 5 per cent. The basal metabolism of the fœtus is very high per unit of weight, but its smallness precludes any great increase in the total metabolic activity of the mother. During lactation the energy demands are slightly greater because of the need to produce a milk containing the correct amount of energy-producing substances as well as ample supplies of proteins, mineral salts and certain vitamins.

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CHAPTER VI

PROTEIN REQUIREMENTS OF THE BODY

PROTEINS have the function of building up new tissue in the growing animal and of repairing the wear and tear of tissue in both the young and adult animal. For this purpose the proteins of animal foods are better than those in foods of plant origin. The best proteins are obtained from milk, eggs and glandular tissues (kidney, liver, pancreas, etc.). This stands to reason, since these foods contain the proteins best adapted for the purpose of supporting mammalian life. Some may ask, "Just what do you mean by a protein?" The question is not easy to answer without reference to the chemistry of the proteins. Proteins are present in all living tissues and so intimately are they bound up with the structure of the body that it is difficult to find examples of a pure protein existing separately. The best example of a protein is egg-white. This is a pure protein in solution in water. Egg-yolk is a mixture of proteins with fat and salts, just as are cheese and meats. The proteins are made up of numerous nitrogenous compounds or units linked together: these units are called amino-acids, and in the constitution of a protein some 12 to 18 amino-acids are bound together. In the process of digestion these amino-acids are broken from their linkages one with another and are separately taken up by the blood stream and carried to the tissues of the body, where a selection of amino-acids is made for the building up of the various types of proteins which constitute the tissue. Different tissues require different amino-acids. For example, skeletal muscle selects different amino-acids from those which would be selected by the liver for its repair. A German physiologist called these amino-acids "building stones". We can see then that the building or repair of the body is something like the building of a city. In the construction of a cathedral or a college, stones of different shapes and sizes are required; in building bungalows or houses, different types again come into use. The building stones used are determined by the design and that is again determined by the use to which the complete building is to be put. So it is with

the tissues and organs of the body; their function determines the type of building stones or amino-acids which must be selected from the blood. Such a diverse selection as that which is characteristic of the human body demands a rich supply of all possible amino-acids. Every protein in the body is continually renewing its structure, constantly selecting the appropriate amino-acids from the large supply presented to it by the blood. But no single protein in our food contains all the necessary amino-acids. Numerous proteins must therefore be present in the diet. The most important element in the amino-acids is nitrogen; the others are carbon, hydrogen, oxygen and sulphur. Fortunately we find that the individual proteins contain, not merely one amino-acid, but several different amino-acids, and also many of each. About fifty proteins have been chemically examined and it has been found that they contain usually twelve to fifteen amino-acids, all of which, however, are not required by the body.

An important point must be mentioned here. The body has the power to synthesize or build up from simple combinations of carbon, hydrogen, oxygen and nitrogen, certain of the required amino-acids. Those amino-acids which cannot be built up must be supplied by the protein of the food. Some proteins in our foodstuffs do not contain these essential amino-acids and they are known as incomplete or deficient proteins. Proteins which contain all the amino-acids which have to be supplied by the food for growth and repair are called first-class or, better, complete proteins.

A considerable degree of interest has developed around this question of the ‘ completeness ’ or as it is called the ‘ biological value ’ of the proteins. By the term ‘ biological value ’ is meant the ability of any protein, such as that in meat, milk, eggs, wheat, oats, etc., to provide for the growth of the young animal and the maintenance of the adult. Recent work on this subject has shown that the biological value of the mixed proteins in normal dietaries is surpassed only by that of the proteins of eggs and milk. Proteins of maize and wheat are well balanced with respect to amino-acids required for growth and compare favourably with amino-acids of animal origin. This indicates that the process of amino-acid supplementation which takes place in a normal diet is effective in compensating for the varying deficiencies of the individual proteins composing

it. The incomplete proteins play a part in enhancing the nutritive value of proteins of a higher biological value than they themselves possess. The nutritive value of individual proteins depends on three factors; (1) the amount, (2) the digestibility and (3) the biological value of the protein. Consider these three points briefly :—

(1) No protein unless in adequate supply will produce its full nutritive effect.

(2) Digestibility is associated with the form in which the protein exists in food as eaten and the extent to which it is broken up by the enzymes or ferments in the alimentary canal. In general terms, proteins of animal origin are more easily digested than those of vegetable origin, with one exception, the protein of uncooked egg-white. If one takes the coefficient of digestibility of milk and meat protein as 98 (i.e. for every 100 grams of protein nitrogen consumed 98 would be utilized), that of cereals and legumes would be 90 and 70 respectively. The low figure for the proteins of cereals and vegetables is due to the presence in such food of large quantities of indigestible cellulose which protects the protein from enzyme action. When proteins, isolated from the structural elements of cereals and vegetables, are tested they have a digestibility coefficient not far removed from that of meat or milk.

(3) The biological value of a protein depends upon the amino-acids of which it is composed. Some proteins have amino-acids which will fully make good wear and tear and also support growth. These are called complete proteins; others are very good for maintenance but will not support growth, these are partially incomplete; others again can support neither maintenance nor growth, these are called incomplete proteins.

The proteins of highest biological value, that is, the complete proteins are found in eggs, milk, cheese, meats and nuts. In vegetable and cereal foods an incomplete protein is often associated with a complete protein and in some vegetables the protein may be wholly incomplete. The following table shows the nature of the protein in certain foods.

The further development of this subject demands a knowledge of the various amino-acids in these proteins. The complete proteins contain amino-acids which, since the body cannot build them up from simpler compounds, must be

TABLE 9

Food	Complete Proteins	Incomplete Proteins
Meat . . .	Albumin and myosin	—
Milk . . .	Caseinogen and lactalbumin	—
Eggs . . .	Ovalbumin and ovovitellin	—
Wheat . . .	Glutenin	Gliadin
Gelatin . . .	—	Gelatin
Soya bean . .	Glycinin	Legumin
Barley . . .	—	Hordein (partially)
Maize . . .	Glutelin	Zein
Almonds and nuts .	Excelsin	—
Peas . . .	—	Legumin

present in the food. While cereals and vegetables have incomplete proteins, i.e. proteins lacking the 'essential' or indispensable amino-acids, it must not be thought that these incomplete proteins are of little value. Most important in this respect is the fact that small amounts of complete protein have a strong supplementary effect on incomplete proteins. For example, a piglet fed on corn does not grow well because the complete protein, glutelin, has no great supplementing action on the incomplete protein, zein. But if to the diet of corn a small amount of milk be added, giving the complete proteins caseinogen and lactalbumin, the rate of growth is almost fully restored. This is but a small example from many which emphasize the importance of a good mixed diet, e.g. cereals and milk ; meat and vegetables ; cold meat with a mixed salad of greens, eggs, tomatoes and mayonnaise. This is the death knell of all dietary faddism which separates animal from vegetable proteins, proteins from carbohydrates, and starches from everything else. In practical dietetics there is safety in mixtures !

The Protein Requirements of the Body.—Protein, which is required for energy and body building, is an essential part of every cell in the body. It is present in large amounts in inactive tissues such as bone. Muscle consists of 75 per cent water and 25 per cent of solid material, and of this solid material 80 per cent is protein, the remaining 20 per cent is made up of extractives and inorganic salts.

The question arises, " How much protein is required for body building, how much for energy ? " The child requires

protein for growth; as much as one-third of the total intake of protein may be used for growth. The adult requires but little for repair. It is important to remember that muscular work does *not* entail any appreciable breakdown of body protein. Work determines energy needs but such energy needs are supplied by carbohydrates. Muscular work is not done primarily at the expense of protein, but long continued work does produce an increase in the breakdown of muscle protein, which being formed into glucose makes good any reduced carbohydrate supply of the body. And here it might be mentioned that mental work also does not appreciably increase the energy needs of the body. Another important point is that the body does not store protein as it stores fat and carbohydrate; all nitrogenous material in excess of that immediately required is excreted by the kidney. To have the excretory organs burdened with the excess of the products of protein breakdown is a disadvantage. Those amino-acids of the protein which are used for the building of tissue have their nitrogen built into the body structure, while all those which are in excess have their nitrogen removed by conversion into new nitrogen-containing substances which must be excreted; the remainder, i.e. the non-nitrogenous part, carbon, hydrogen and oxygen, must be burned and is got rid of as CO_2 and water. A few figures will illustrate the extent of these two quotas of protein, viz. protein incorporated in the body tissue and protein burned as a source of energy.

A man weighing 70 kilograms or 154 lb. generally requires about 70 grams of protein per day. The figure varies. For example, in this country and in the United States of America, those who take rich protein food may ingest from 80 to 120 grams of protein per day. An Esquimo who lives on meat may take 300 grams; a vegetarian in the Tropics, e.g. a Hindu, may take not more than 50 grams per day. And curiously enough the former lives on a plentiful supply of animal protein while the latter exists on a meagre supply of protein of rather poor quality. It has been shown experimentally that not less than 30 grams of protein must be assimilated to make good the wear and tear of the body. Any protein in excess of this figure will be used for the production of energy. The extent to which protein is burned for fuel depends upon the degree to which the body utilizes carbohydrate and fat for energy. If in the

adult there is an adequate supply of carbohydrate for energy, protein need never be used specially for this purpose. The protein intake, in diets liberal in energy-producing carbohydrates and fats, should always be in excess of the minimum requirements of the body for growth and repair. Much scientific

TABLE 10

TABLE SHOWING MAN VALUE COEFFICIENTS, TOTAL CALORIES AND TOTAL PROTEIN REQUIREMENTS

Compiled from figures from the N.R.C. (U.S.A.) and from Dr. Cuthbertson "B. Med. Bull.," 1944

Age in years, Children	Man Value Coefficient	Total Calories	Protein g./kg.	Total Protein g.	1st Class Protein g.	Percentage Calories derived from Protein
1	0·36	900	4·0	36	36	16·0
2	0·48	1200	3·4	40	30	13·7
3	0·56	1400	3·3	46	33	13·1
5	0·64	1600	3·0	50	35	12·8
8	0·80	2000	2·8	65	40	13·3
11	1·00	2500	2·5	80	45	13·1
14 (girls)	1·12	2800	2·0	90	45	13·2
14 (boys)	1·28	3200	2·3	100	50	12·8
16 (boys)	1·40	3500	2·0	105	50	12·3
18 (girls)	0·96	2400	1·25	70	40	12·0
18 (boys)	1·52	3800	1·84	110	50	11·9
Man—65 kg. Moderately active	1·20	3000	1·15	75	40	10·6
Very active	1·68	4200	1·7	110	50	10·7
Sedentary	1·0	2500	1·0	65	35	11·1
Woman—58 kg.						
Moderately active	1·0	2500	1·12	65	35	10·7
Very active	1·28	3200	1·37	80	40	10·3
Sedentary	0·84	2100	0·85	55	35	10·7
Pregnancy (latter half)	1·00	2500	1·15	75	50	12·3
Lactation	1·20	3000	1·46	95	60	13·0

controversy has been waged over the minimum intake of protein necessary for healthful living. Chittenden in Boston maintained that men could live well on a protein intake of 44 grams per day. This has been criticized by German and English workers, who have shown that a minimum protein diet

ultimately results in a lack of robustness or vitality and a predisposition to infectious diseases. In experiments on rats—and standard rats give results which are of great value in leading to conclusions which are of importance for man—it has been found that minimal protein diets continued over three or more generations lead to very definite deficiencies. It may be that the second generation reveals nothing that could be interpreted as abnormal, but the third generation invariably shows changes in size, rate of growth, number of litters and, what is noteworthy, in the number of deaths in the litters. When dogmatic criticisms are levelled at scientific findings, it is well to ask if such criticisms are based on results covering three or four generations.

For children and adolescents it may be maintained that about 13 to 16 per cent of the total Calories should be furnished by protein, while for adults 10 to 11 per cent is regarded as sufficient. If we consider the Calorie and protein requirements of children, adolescents and adults (Table 10) in relation to age and weight we shall find that these percentages are substantially correct. Take three examples.

(1) A child, aged 8 years.
Weight = 50 lb. = 23 kilograms.
Calorie coefficient = 0·8 = 2000 Calories.
13 per cent of 2000 = 260 Calories = 65 grams protein.
Protein requirement by weight = 2·8 × 23 = 64 grams protein.

(2) An adolescent boy, aged 16 years.
Weight = 118 lb. = 54 kilograms.
Calorie coefficient = 1·4 = 3500 Calories.
12 per cent of 3500 = 420 Calories = 105 grams protein.
Protein requirement by weight = 2·0 × 54 = 108 grams protein.

(3) An adult, moderately active, aged 25 years.
Weight = 143 lb. = 65 kilograms.
Calorie coefficient = 1·2 = 3000 Calories.
10 per cent of 3000 = 300 Calories = 75 grams protein.
Protein requirement by weight = 1·15 × 65 = 75 grams protein.

A study of tabular data in this manner impresses upon one the great need of the growing body for protein. A little further

calculation will show that a child of 1 year weighing 20 lb. requires 36 grams of protein, and all of it must be animal protein. It may be safely affirmed that from the age of 6 years onwards the human body should have 40 to 50 grams of animal protein daily. If this be available, the rest, be it 25 or 50 grams, can be secured from cereal and vegetable sources of protein supply.

Table 10, which links up Calorie with protein requirements, should be consulted for details concerning age groups.

We see, therefore, that we begin life with a very high protein requirement, in terms of body weight, namely, 4 grams per kilogram of body weight, that this falls steadily throughout adolescence and that, adolescence safely passed, no one, unless very actively engaged in manual work, need ingest more than 1 gram of protein per kilogram of body weight, or 0·5 gram or $\frac{1}{60}$ oz. per lb. of body weight. We realize something of the biological value of protein as building material when we compare the protein content of the milk of the mother with the rate of growth of the newborn progeny. Note how rapidly a kitten, a lamb, a piglet, or a calf doubles its birth weight compared with the time taken by a human baby. Note also the amount of protein in the milk of the cat, the ewe, the sow, the cow and the human mother.

The kitten doubles its weight in	7 days ;	Protein of milk = 9·5 g. %
The lamb ,, ,, ,,	10 days ;	,, ,, = 6·3 g. %
The piglet ,, ,, ,,	3 weeks ;	,, ,, = 5·2 g. %
The calf ,, ,, ,,	7 weeks ;	,, ,, = 3·5 g. %
The baby ,, ,, ,,	6 months ;	,, ,, = 1·3 g. %

While a baby thrives on cow's milk, the calf would fade away on human mother's milk, and the lamb on a similar diet may succeed in standing on its feet before it died, which event would probably take place in about one week.

The reason for the presence of protein in the diet is to provide nitrogen, sulphur and phosphorus in the form of amino-acids for growth, maintenance, reproduction and lactation.

The Sparing Action of Carbohydrate and Fat on Protein.—It has long been known that carbohydrate has a sparing action on protein metabolism. Several investigators have shown that if a man be starved, the output of nitrogen in the urine falls. This indicates that, after the first two days of inanition, when carbohydrate stores have been rapidly diminished, the body obtains energy from protein and fat. When, as in

the last stage of severe or prolonged starvation, almost all fat has disappeared, the body has to rely on its protein for the supply of energy. The loss of protein can, however, be stopped if carbohydrate be administered in amounts sufficient to meet the energy requirements of the resting man, i.e. about 35 Calories per kilogram. Whenever the protein wastage stops, the tissues will be restored by a rebuilding of the protein part of their structure. This is the extreme case and here only carbohydrate, as glucose, is effective. If the diet be sufficient in protein and the body is in nitrogen balance, the addition of carbohydrate to the food will result in a storage of protein, indicated by a diminution of nitrogen excreted in the urine. On the other hand, while retaining the same protein and calorific values of the diet, the latter by adding fat, all carbohydrate be withdrawn, then the nitrogen output will increase, indicating a greater oxidation of protein. Whenever the carbohydrate is restored, the degree of breakdown of protein returns to normal. Physiologically adequate amounts of carbohydrate thus spare protein, not only by serving as fuel so that the protein is not called upon for energy but also by forming combinations with the products of protein breakdown from which amino-acids may be formed. From the results of many biochemical experiments, it has become increasingly clear that carbohydrate plays a very important part in protein metabolism. Cuthbertson and Munro have demonstrated that excess of carbohydrate (280 Calories) or fat (700 Calories) in a diet containing 70 grams of protein and supplying 3200 Calories caused a great increase in body weight in man. In a word, the body can only grow to its optimum in size and strength if, in the presence of an adequate amount of protein, it receives its optimal supplies of carbohydrate and fat.

The question, " How much protein should be taken ? " has been answered. It naturally leads to a second question, namely, " How can we secure the correct proportion of protein in our diet ? " Let us answer by asking a few questions.

" What are the protein rich foods ? " They are eggs, meat, cheese, milk, legumes and nuts.

" Where are the complete proteins to be found ? " In milk, cheese, eggs, meats and most nuts.

" Where are the incomplete proteins to be found ? " In grains and vegetables.

"How then are we to secure 45 grams of animal protein?" By taking the following foods :—

Foodstuff	Amount	Protein (grams)	Calories
Milk . . .	1 pint	19	360
Egg . . .	1	6	78
Meat . . .	4 oz.	20	270

This gives 45 grams of animal protein and 708 Calories. A further 25 grams of protein can be secured by eating grains and vegetables, thus giving the optimum. So much for the adult, but what of the child? According to Sherman, "given a full quart of milk in the daily dietary of the growing child, the other foods may be selected chiefly with reference to qualities other than their protein content. Without a liberal use of milk, the proper feeding of the growing child becomes a very difficult problem." Eggs, cereals, with a little meat occasionally, will raise the total protein in the diet of a child to about 15 per cent of the total Calories if the quart of milk is adhered to. It is not necessary as some erroneously think that the child should drink the quart of milk. It should appear in any form in the daily dietary.

Table 11

FOODS RICH IN PROTEIN

	Grams per 100 grams		Grams per 100 grams
Cheese	25–37	Haddock	16
Egg, raw	12	Herring	16
,, white	9	Lemon sole	16
,, yolk	16	Whiting	16
Milk, whole	3·3	Salmon	17
,, dried	26		
,, condensed	7	Almonds	20
,, ,, skimmed	9	Peanuts	28
		Beans, butter	19
		,, haricot	21
Bacon, Wilts.	14	Lentils	24
Beefsteak	19		
Ham	15	Chocolate, milk	7
Liver	16	,, plain	5
Mutton	18		
Bovril	29	Cocoa powder	20

The energy and protein requirements of pregnancy and lactation are as stated in Table 10. Dietary surveys carried out recently by the sub-committee on Nutrition of the Department of Health for Scotland have shown how serious has been the deficit in animal protein in the diets of nursing mothers (Cruickshank, 1946). Priority supplies of milk have been of great value, but to secure the required 60 grams of animal protein every nursing mother should have $1\frac{1}{2}$ to 2 pints of milk and one fresh egg or its equivalent per day.

There has been some exaggeration of the ill-effects of taking moderately liberal amounts of protein and a confusion of these with the effects of eating too much meat. Intestinal putrefaction does not necessarily accompany the ingestion of too much protein. Intestinal hygiene can be maintained with milk, eggs, cheese, grains, vegetables and moderate amounts of meat.

A liberal protein consumption with a moderate amount of meat is better than a restricted protein intake or a poor protein intake such as is obtained with a vegetarian diet.

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CHAPTER VII

FOODSTUFFS AND THEIR FUEL VALUES

CARBOHYDRATES, FATS AND PROTEINS

The Source of Energy.—In physics energy is defined as the ability to do work; in biology energy may be regarded as a force which manifests itself in various ways, as work, heat, light or electricity. The energy or fuel value of foods is always stated in Calories, a Calorie being the heat unit. Units of heat and mechanical work are mutually convertible and it is therefore possible to transform Calories into units of work (foot-pounds or gm.-cm.): this, however, is not done in dealing with foods. In the utilization of food, heat is produced and work is done; and if the energy intake is in excess of the needs of the body, it is stored as carbohydrate and fat. The sun is the source of all energy in the form of light and heat. Man can become a partaker of solar energy through the medium of the food he eats. In virtue of chlorophyll, the green pigment which they contain, plants store energy in the form of various chemical compounds such as carbohydrates and fats which are made up of carbon dioxide from the air, and water from the soil. Plants are also able to synthesize or build up proteins from *simple inorganic nitrogenous substances*, or in some cases, by making use of atmospheric nitrogen. This remarkable achievement is something of which the animal body is incapable, and, therefore, to secure his protein man must depend upon a preformed supply in his diet. The body can build up proteins if given rather *complex organic* nitrogenous substances, which are formed in the alimentary canal as the result of the digestion of preformed animal or vegetable protein.

The Fuel or Energy Value of Carbohydrates, Fats and Proteins.—It has been stated that the energy value of carbohydrate is 4·1 Calories per gram. This is an average figure because the term carbohydrate covers glucose, cane sugar and starch, the energy values of which are 3·35, 3·95 and 4·23 Calories per gram respectively. For fats, the energy value as determined by total combustion of a fat in the calorimeter

is 9·45 Calories per gram, for protein 5·35 Calories per gram. But in calculating the fuel value of carbohydrates and fats, allowance must be made for the loss during digestion of approximately 2 per cent in the case of carbohydrate and 5 per cent in the case of fat. While carbohydrate and fat are oxidized to carbon dioxide and water, protein is oxidized in the bomb calorimeter to carbon dioxide, water and nitrogen. When burned in the body, protein yields no free nitrogen ; the nitrogen is eliminated as organic nitrogenous compounds —urea, uric acid, creatine, etc.—in the urine, and the amount of heat lost is about 1·10 Calories per gram of protein digested. Heat is also lost by the elimination of nitrogen in the fæces, and heat is required for the solution of proteins and urea ; this further increases the heat loss by 0·23 Calories per gram of protein digested. The total heat thus lost is 1·33 Calories and must be subtracted from the original figure, 5·35, leaving 4·02 Calories as the physiological heat value of one gram of protein. Thus the following final figures for the calculation of the fuel values of the three proximate principles of our food, in Calories per gram, are :—

Carbohydrate 4 ; Fat 9 ; Protein 4.

Knowing the composition of any food in terms of protein, fat and carbohydrate, we can determine its fuel value ; for example, 100 grams or 3·57 oz. of milk gives

Protein . .	3·3 grams × 4 = 13·2	Calories
Fat . . .	3·6 grams × 9 = 32·4	,,
Carbohydrate .	4·4 grams × 4 = 17·6	,,
	63·2	,,

Tables of food values have been drawn up in many countries and are repeatedly under revision. In this country the latest figures dealing with the energy and nutritive values of war-time foods have been issued by the Medical Research Council, in War Memorandum No. 14, 1945.

When energy and nutritive requirements are set out in Tables the figures relate to physiological needs as satisfied by uncooked food. This implies a knowledge of waste in the cooking of various foodstuffs, and therefore when cooked, canned or preserved foods are used, appropriate Tables must be consulted.

Allowance is made for this in many of the more recently issued Tables.

Sugars and Starchy Foods.—To most people sugar is that sweet granular foodstuff which appears on the table. It is cane sugar and is made from the sap of the sugar-cane. Cane sugar, or sucrose, is present in the juices of sugar-cane, beetroot, and sugar maple. Sucrose is composed of equal parts of glucose and fructose. These three sugars, glucose, sucrose and fructose, are most commonly found in the sap of many plants and in the juice of fruits, for example, fructose is found mixed with

TABLE 12

FOODS RICH IN SUGAR

	Per cent		Per cent
Granulated sugar	100	Sultanas (dried)	65
Brown sugar	98	Dates (dried)	64
Maple sugar	83	Raisins (dried)	64
Syrup (golden)	79	Currants (dried)	63
Honey	77	Condensed milk (sweetened)	56
Marmalade	70	Chocolate	55
Treacle (black)	67	Figs (dried)	53

FOODS RICH IN STARCH

Tapioca	95	Rye	80
Sago	94	Ryvita	79
Cornflour	92	Semolina	77
Arrowroot	90	Macaroni	77
Rice (polished and raw)	87	Oatmeal (raw)	73
Maize	85	Toast (average)	64
Barley	81	Bread (white)	53
Flour (white)	76	Lentils (raw)	51
,, (wholemeal)	67		

glucose in honey and in fruit sugar. Besides these there are other two sugars of importance, namely maltose or malt sugar and lactose or milk sugar. Molasses, much used on the American continent, is a concentrated vegetable juice which contains a good deal of calcium and iron along with the sugar. Starch is found in seeds, tubers and roots of plants. The starch, wherever found, is chemically the same. It is to be found in the plant in envelopes of cellulose, which are called grains or granules, and each plant has a characteristic form of granule, so that one can readily distinguish wheat starch from potato starch when the grains or granules are examined under a microscope. In unripe fruits starch is present, the banana is an

example. In the form in which it is eaten it is not completely ripe ; as it ripens, the starch is converted into sugar.

Cooking ruptures the granules, changes the starch chemically, makes it more soluble and therefore more easily digested. All these sugars and starches are classed under the term carbohydrate, a name given because of the elements carbon, hydrogen and oxygen, which alone make up these substances. Practically all these carbohydrates used for food come from the vegetable kingdom. The sugar found in the blood is glucose ; it is stored in the liver and muscles as glycogen, which is a combination of glucose molecules, and is sometimes called animal starch. Milk sugar, a carbohydrate of animal origin, is found in milk and is the only sugar of animal origin. When the term " carbohydrate foodstuff " is used, it does not necessarily imply that only sugar is to be found in the food referred to. Many carbohydrate foods, e.g. wheat, milled rice, which are almost pure starch, contain 9 to 11 per cent protein ; but certain vegetables, e.g. dried beans and peas, have 60 per cent starch and 20 per cent protein. Potatoes, regarded as a very starchy food, contain about 18 per cent of starch, 2 per cent of protein, and 78 per cent of water. Potatoes and milk are very watery foodstuffs (milk 87 per cent water), but nevertheless they are very valuable foods because they are consumed in comparatively large quantities.

Foods are always grouped according to their richest constituent.

FACTS ABOUT CARBOHYDRATE AND FAT RICH FOODS

Grains.—The cereal grains have formed the chief sources of food supply for all people since agriculture began. They are easily cultivated, can be stored for long periods, are palatable and economical. Of the cereal grains, wheat, rye, barley and oats have formed the main food supply of the peoples of Europe and America for many centuries, while rice has been the staple diet of the Chinese and Japanese from time immemorial. While it is a commonplace to say that " bread is the staff of life ", it is astonishing, to all who look into the figures for bread consumption in our industrial areas, to realize the extent to which the working classes cling to this staff of life, even to the

exclusion of equally nourishing foods. Many are indeed incredulous when informed that thousands of men and women eat no less than 7 lb. of bread per head per week. It may be said that the amount of white bread eaten is an indication of the standard of living of the great mass of working people in this country. Wheat and other grains are, however, coming into much greater use in this country than was the case some 15 or 20 years ago. The cultivation of wheat has developed tremendously, due to scientific research, whereby many grains, especially wheat, have been adapted to dry regions. In

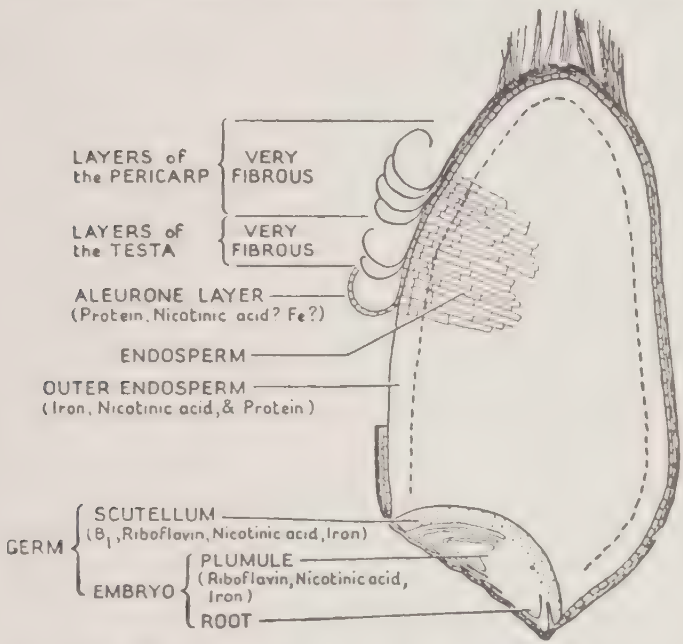

FIG. 8.—The distribution of nutrients in the wheat grain (*Sir J. Drummond and Dr. T. Moran.*) (*By courtesy of The Lancet.*)

Canada the Red Fife wheat, which originated from a single grain of Galician wheat included in a sample sent to a farmer, David Fife, from Danzig in 1847, held the field until superseded by the Marquis, which had a shorter growing period and could therefore be cultivated further north. In this way the wheat belt was extended northwards. In the United States drought-resisting strains were introduced from South Russia. Australia has developed wheats which can ripen on lands which receive only 15 inches of rain annually. The story could be extended to India and Egypt where British engineering feats, coupled with agricultural research, have greatly added to the wheat

production of the world. Barley and rye are grown where wheat does not thrive, e.g. in parts of Germany, Denmark and the United States of America. Oats, while of no value for breadmaking, have in the form of porridge and oat cakes "general nutritive qualities greater than those of any other cereal" (Bogert). To prepare the grain for human consumption it must be milled. Milling removes the husk, the outer coats or bran and the germ, which must be removed if the flour is to be stored, otherwise it will deteriorate. It is known that a too complete milling removes fat with the germ, protein, vitamins and salts with the outer layers (see Fig. 8). All the protein and the salts are, however, not removed, as some are present in the endosperm or kernel. Rice that has been highly milled and polished is an example of the worst that can befall any grain, for by these processes the germ, bran and outer coats are all removed. The tremendous loss in salts is accompanied by a complete loss of vitamins. White flour represents a degree of milling in which the outer coats only have been removed; there is therefore not any great loss of protein. The whole flour is the ideal form in which the grain should be used, as then there is no loss of proteins, vitamins or mineral salts. Further reference will be made to this subject when dealing with bread.

Sugar.—This is a most highly refined and concentrated food. Three hundred years ago sugar was unknown as an article of diet. In the days of Marie Antoinette it was an expensive luxury sold at about 4s. or 5s. per lb. At the end of the Napoleonic wars, which had cut Europe off from her source of sugar supplies, France and Germany had established the manufacture of sugar from beet, but English people had insular prejudices concerning beet sugar and were apparently content to pay dearly for cane sugar which was rapidly becoming a necessity. The history of sugar is the history of a habit-forming foodstuff. We are all aware of the naïve way in which many persons satisfy their craving for sugar. The manufacturers of sugared sweets need no slogan. Like alcohol, tobacco, morphine and cocaine, sugar has its addicts, and they are not all in the United States and Canada; as sugar consumers we run a very close second to the people of the Northern American continent. From 1836 to 1936 the consumption of sugar has risen from approximately 10 to

100 lb. per head per annum. The great increase in the use of sugar has not been without its effect upon our taste for other and better foods. The craving for sugar has led to the use of unbalanced diets, for sugar in excess destroys the appetite for those foods which supply the all-essential proteins, vitamins and mineral salts. It does this because a concentrated sugar solution is hygroscopic, that is, it will take up water. Here, then, is the cause of that irritation of the mucous membranes of the stomach and intestines which follows a too great indulgence in sugar. The greatest danger physiologically lies in the fact that sugar, which is not a body builder but a source of energy, so quickly satisfies the appetite that it abolishes the desire for other foods. The importance of this fact to the growing child is at once evident. Body building and energy are the two vital needs of the child. It is not unfortunate that energy requirements can be so readily supplied by those things for which the child craves ; but it is unfortunate that the body-building foods cannot be so easily nor so cheaply supplied. No child should be allowed to come to a meal with an appetite cloyed by a too free indulgence in sweets or candy. Sweets should always be given at the end of a meal and it is for this reason that the best form of dessert are those fruits which contain small amounts of sugar.

In the adult the continued excessive consumption of sugar may lead to a weakening of the pancreatic gland whose function it is, by means of insulin, to control carbohydrate metabolism. A diminution in the production of the hormone, insulin, leads to a failure of the body tissues to burn and to store sugar which is presented to it by the blood. When this happens blood sugar rises and overflows through the kidneys, giving rise to those signs which are indicative of diabetes. Other untoward results of excessive intake of sugar are liver disorders, arthritic troubles, overweight and all the ills that follow in its train. Many of the vague ills that flesh was heir to before the war could have been dissipated by eating less carbohydrate, either as potatoes, chocolates or highly sweetened desserts. It is an interesting point that starches do not tend to cause so much trouble as the sugars. This is due to the fact that starch is digested gradually, being broken down to dextrin and maltose by the enzyme pytalin in the saliva, a process which goes on in the stomach, and to glucose by maltase in the intestine. The

prolonged digestion of the starch with the rapid absorption of the glucose as it is formed is the reason for starch causing so little digestive disturbance. Excessive use of starch will of course lead to the same ills which are attendant upon an excessive sugar consumption. The points to be remembered about foods rich in starch are that they are deficient in vitamins, proteins, fats and mineral salts. Where starches form the greater part of the diet there do we find bad teeth, poor bone development, anæmia and a diminished resistance to infection. It is for this reason that starches and sugars, valuable and economical sources of energy though they may be, must be supplemented by eggs, milk, fruits and vegetables.

Fats.—Fats are found mainly in foods of animal origin. Being unable to store large amounts of carbohydrate, the animal body transfers carbohydrates into fat which is stored in almost every part of the body. Fat thus serves two purposes, as a reserve of energy and to prevent heat loss from the surface of the body. Although the fats are mainly of animal origin a few plants have the power to store fats in considerable amounts in their fruits and seeds. Examples of plant or vegetable oils are olive oil, cocoanut oil and cotton-seed oil. Nuts are very rich in fats. Fruits generally are not well supplied with fat. Vegetable fats are spoken of as oils because at ordinary temperatures they are liquid. Animal fats at room temperatures are solid or semi-solid. Every fat has its definite melting-point; the fats which have lower melting-points than the temperature of the body (37·5° C.; 98·4° F.) are digested more easily than those which remain semi-solid in the alimentary tract. The following are the melting-points of certain fats :—

Butter fat	28–33° C.
Pork fat	36–46° C.
Beef fat	40–48° C.
Mutton fat	46–50° C.
Human fat	17·5° C.

The fats found in milk, cream and egg-yolk are the most easily digested because they are in the form of an emulsion, i.e. the fat is present in very fine droplets which allows the digestive juices to surround and attack them. Fats are adapted to the animals and plants in which they are found. Plants

and cold-blooded animals, e.g. fish, have fats of low melting-point so that when we use them they are generally in the form of oils. Cattle and sheep have fat which is slightly harder than that of pigs, the latter being largely herbiverous animals.

The most used animal fat is butter, made from the milk of the cow, or, as is common in many countries, from the milk of the goat or Indian buffalo. Milk and cream are very valuable sources of fat. In the former the percentage of fat is 3·6 ; it may be as high as 4·0 per cent ; it should not be less than 3·5 per cent. In the latter the fat content varies from 18 to 40 per cent. In eggs the fat is contained exclusively in the yolk, where it averages 30·5 per cent. In the whole egg as bought, which weighs about 50 grams or $1\frac{3}{4}$ oz., the amount of fat is approximately 6·0 grams.

Cheese made from cream contains a large amount of fat ; certain cheeses are very rich in this respect, containing up to 86 per cent of fat. In fish, fat is stored in the liver in the form of oil and hence fish livers are the source of very valuable oils, e.g. cod-liver oil, halibut-liver oil, etc. With the exception of herring, salmon, mackerel and trout there is very little fat in the flesh of fish.

The Value of Fat in the Diet.—Fat has a fuel value more than double that of an equal amount of either protein or carbohydrate. The following foods in the amounts stated are of equal calorific or fuel value : 1·0 oz. of butter, 2·1 oz. of carbohydrate, 2·4 oz. of meat, 2 lb. of cabbage and 3 lb. of lettuce. The high calorific value of fat makes it possible to increase markedly the fuel value of a diet without any appreciable increase in its bulk. To put on weight is thus a comparatively simple matter. A little more butter, a liberal use of mayonnaise dressing and an ice cream occasionally will work wonders. To see the menu in any Canadian or American hotel with its double chocolate sundaes, its banana splits garnished with cream and nuts and a dozen other such delicacies, is to realize one of the factors responsible for the good physique of, and the display of confidence by, the American peoples. To cut out sugars and starches from the diet and to continue with ice cream sodas, nuts and salads with mayonnaise, will never help those who sigh over the ideal of the " willowy figure ". It is usually a very simple matter to reduce the fuel value of a diet. Marked reduction can be made by omitting all definitely fatty

foods, eating sparingly of butter and banishing from the table all rich salad dressings.

In so far as fats are concerned the vitamin content varies considerably. Vitamin A, while it is contained in butter and egg-yolk, is entirely absent from fats of vegetable origin. It is for this reason that vegetable fats are not substitutes for animal fats; and so it is with butter substitutes, those made from vegetable oils are of no value in this respect unless vitamin A has been added in their manufacture. Butter substitutes are excellent if they contain vitamin A and if by using them more milk and eggs can be bought. The two fat soluble vitamins, A and D, are to be found in the livers of all fish, particularly

Table 13

FOODS RICH IN FAT (EDIBLE PORTION)

	Grams per 100 grams		Grams per 100 grams
Olive oil	100	Sardines (in oil)	23
Butter	83	Herring (raw) (Summer)	18
Margarine	85	Salmon	15
Cheese, cheddar	34	Mackerel	8
,, cream	86		
Bacon (average)	38	Almonds	53
Ham (average)	39	Barcelona nuts	65
Mutton and pork	(variable)	Brazil nuts	61
		Cocoanut (dessicated)	62
Lard	99	Chocolate, milk	34
Suet	99	,, plain	32

those of the fatty fish. This is the source from which the well known highly concentrated preparations of these vitamins now on the market are manufactured. Fats form one of the most important assets in the life of a nation, both in peace and in war. It is amazing how greatly people vary in their ability to digest and assimilate fat. Fat tends to delay digestion, which explains why a meal with fat gives a sense of satiety. Herein lies the staying power of a meal. It is well known that "porridge and milk do not keep the stomach for long", for the simple reason that they are quickly digested. If one wishes to go from 8 a.m. to 1 p.m. without feeling very hungry at noon one should when possible add an egg or egg and bacon to the breakfast menu. Such an addition, while prolonging digestion, adds considerably to the fuel value of the meal.

Dietary rules for the use of fatty foods are quite simple, for most people are aware of the disadvantages of a too fatty meal. For young children and those with weak digestions, fried foods, fat meats and pastries should be excluded from the diet. The most easily digested forms of fat are those in which the fat is well emulsified, namely milk and eggs. Butter is usually well digested by most, this is due to its low melting-point. Ice cream is a very good form in which to add fat to a diet. Cheese also is an excellent medium for fat as it is for protein. It is self-evident that the heavily fatted foods and fried foods should always be taken in moderation. Cakes, pastries and puddings are very rich in sugar or starch and fat, and can play a useful role in one direction only.

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CHAPTER VIII

MINERAL SALTS IN NUTRITION

While proteins, fats and carbohydrates have been stressed as all-important for the body, there are other substances having no energy or fuel value which are of vital importance for the growth and well-being of the individual. These are the mineral salts, those inorganic elements which form the ash constituents of the body. They may be present in simple form, as inorganic salts, or in complex organic combination. In the following Table is given a list of the chemical elements, showing their percentage amounts in the human body and the daily intake necessary for an average adult.

Table 14

CHEMICAL CONSTITUENTS OF THE BODY

Element	Per cent	Daily Normal Adult Intake in grams
Oxygen	65·0	—
Carbon	18·0	—
Nitrogen	3·0	—
Hydrogen	10·0	—
Calcium	1·50	0·7
Phosphorus	1·0	1·6
Sodium	0·15	4·6
Potassium	0·11	3·4
Magnesium	0·07	0·34
Sulphur	0·02	—
Chlorine	0·16	7·1
Iron	0·015	0·016
Iodine	Traces	0·00005
Copper, cobalt, fluorine, manganese, zinc	,,	—

One notes at once that oxygen forms almost two-thirds of the body weight. Oxygen and hydrogen in the ratio of one part of oxygen to two of hydrogen form water, which constitutes 75 per cent of the body.

Protein, which contains oxygen, carbon, hydrogen, nitrogen and sulphur, is the only source of nitrogen. Phosphorus is

to be found in the nucleus of the tissue cells. Iron also is present in all cells, including the red blood-cells or corpuscles, where it is responsible for the carriage of oxygen. All these elements are necessary, and the percentage amounts as stated are no criterion of their physiological value. As examples of this, note the small amounts of iron and iodine, both of which, as will be seen later, are so essential for our physical and mental development. The greater part of the minerals of the body are to be found in the bones, the chief mineral constituents of which are calcium and phosphorus. A shortage of these elements in pre-natal life or in the early years is fraught with disastrous results. Certain foodstuffs do not supply minerals; they are carbohydrates and fats. Sulphur is secured through the intake of protein, being found combined with amino-acids, such as cystine and methionine. The lactalbumin of milk is very rich in cystine. Egg-yolk is rich in iron, and for phosphorus the best sources are the vitelline of egg-yolk and the caseinogen of milk. For information as to the mineral content of foods, reference must be made to the appropriate Tables. Since the body does not store minerals to any extent, and since only small amounts are assimilated day by day, the deficiencies of such elements as calcium, phosphorus or iodine become readily apparent. It is, therefore, of importance from a dietary point of view to know something of the requirements for the various minerals particularly in childhood and adolescence.

Calcium and Phosphorus.—Calcium and phosphorus are of great importance for the development of the bones and teeth. A lack of these will result in a retardation of the growth of bone and a loss of its normal rigidity and strength. The bones then show signs of the disease known as ‘ rickets ’, a disease which, while its more outstanding signs have been modified by the general improvement in living conditions during the past thirty years, nevertheless is still to be found in many children. The lack of the usual signs, such as visibly deformed bones, narrow chest, etc., must never be taken as proof of the absence of rickets, for X-ray examination of the ends of long bones often shows that rickets nevertheless exists. It is, of course, an entirely preventable disease. Its treatment demands that in pregnancy a sufficient amount of calcium and phosphorus be taken by the mother, and during the early years of the child’s life, calcium and phosphorus and vitamin D be supplied in the diet.

Calcium requirements can only be studied by noting the amount of calcium taken in the food and the amount excreted in the urine and fæces. From the work of Dr. I. Leitch (1938) the average adult requirement of calcium is 0·55 grams per day, but later work by Steggerda and Mitchell in U.S.A. (1941) would suggest an even higher figure. The National Research Council Committee on Food and Nutrition recommend a daily allowance of 0·8 gram for adults, men and women, regardless of their activity. According to pre-war surveys many diets are well below this figure. Some authorities have stated that 50 per cent of pre-war dietaries were below 0·7 gram per head per day and 16 per cent were below the 0·55 figure. It may be accepted that from 1936 to 1943 the calcium intake of the population considered as a whole has slowly increased. In 1936–38, surveys of the average composition of the diet showed a calcium intake of 0·67 gram, in 1943, apart from the heavy or industrial workers, whose intake was 0·98, the average was 0·76 gram per head per day. The increased average intake was more significant during the war and was associated with an average increase per head of population, in total protein, phosphorus and fat, due to a greater consumption of milk and vegetables and a better distribution of milk and meat. Compared with the requirements scale used at the Rowett Institute which is practically identical with the new American standards based on age and sex distribution, the diets of the families surveyed were still slightly deficient in calcium. In 1944 the consumption of calcium had risen to an average of 0·86 gram per head per day. Calcium is certainly unevenly distributed among the various foods which make up an ordinary mixed diet. Many foodstuffs are very poor in calcium and a diet may, despite an apparent liberality, be lacking in this important element. A continued dietary deficiency in calcium subsequently results in a loss of calcium from the bony skeleton. To make good the loss of calcium from the blood and muscles, a call is made upon the calcium in the bones, where 99 per cent of the total calcium of the body is to be found.

The Calcium Requirements of Children.—Since it is extremely difficult to assess accurately the calcium requirements of growing children, it becomes the more imperative to have more than adequate supplies of calcium in the diet.

Without the least doubt, the best foodstuff in this respect is milk, followed perhaps rather afar off by the green leafy vegetables. The need of a liberal supply of calcium for the young growing animal is shown by the tremendous increase of calcium compared with increase in weight. A rat at birth weighs 5 grams and on a normal diet it will weigh in 3 months 300 grams, a sixty-fold increase in weight. In the same period it will have raised the total calcium content of its body 300 times. It is admittedly difficult to determine for any growing body the optimal amount of any mineral necessary for optimal growth. Reference has already been made to the value of experiments covering three or four generations. Sherman and Campbell (1935) carried out an experiment covering forty generations in rats to show to what extent a surplus of calcium would improve growth and vitality. Briefly, the procedure was as follows : one diet consisted of five-sixths ground whole wheat and one-sixth dried whole milk with the usual amounts of water and salt : the other diet differed from the first by the addition of calcium carbonate to raise the calcium intake from 0·68 gram to 1·36 grams, that is the amount in a pint and a quart of milk respectively. On the part of the males the beneficial results were manifested by slightly greater weight, greater vigour and later senescence. On the part of the females, there were added to these benefits a slightly earlier maturity and a lower death rate among the litters.

More important, however, are the results of experiments on growing children. By changing the amount of milk in the diet of children of ages varying from 4 to 12 years, it has been shown that when the amount of calcium given was 1·36 grams, i.e. equal to 1 quart of milk, the retention of calcium was markedly increased above that obtained with an intake of 0·68 gram of calcium. Greater improvement was obtained in both cases when the calcium was given in the form of milk. This result indicates the importance of giving both calcium and phosphorus in their natural form and in approximately the correct proportion. Reference must here be made to a most valuable type of experiment on pre-school children, boys and girls, 3 to 5 years of age (Daniels, *et al.*, 1935). To an adequate diet was added vitamins A, D and C in the form of cod-liver oil and orange juice. The daily intake of calcium varied between 0·77 and 0·90 gram and the retention of calcium

varied between 9 and 12 milligrams per kilogram daily. Increased amounts of calcium did not appreciably improve the retention. Fig. 9 presents graphically the results of such an

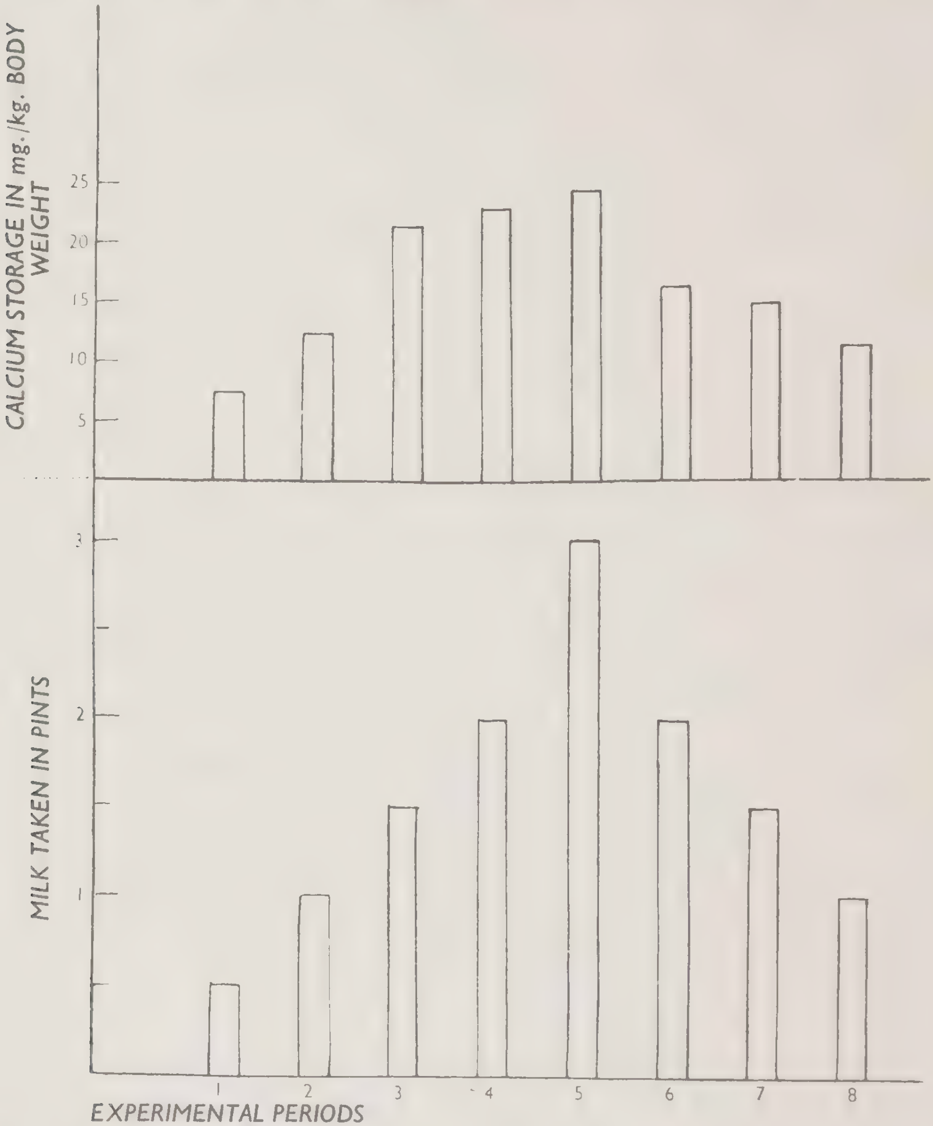

FIG. 9.—Showing the relationship between milk consumption and calcium storage in a girl aged 12 years. (*From data by Sherman & Hawley*, 1922.)

experiment on a girl of 12 years of age. Upon such experiments is based the daily recommended allowance of 1 gram of calcium.

Children between the ages of 3 and 12 years should be given at least 1 gram per day, over 12 years, up to 1·4 grams per day.

This can best be given in the form of milk, 1 quart of which contains 1·36 grams of calcium. Other foods suitable for the supply of calcium are kale, cauliflower, lentils, carrots, cheese and almonds.

In pregnancy and lactation an intake of 1·5 and 2 grams per day respectively is desirable. During lactation the amount of calcium required by the child at the breast increases from about 0·2 to 0·4 gram per day, from birth to the sixth month. The aim should be to secure for the mother 1 quart of milk daily and to make up to the calcium requirement of 2 grams per day by the use of calcium rich foods.

TABLE 15

FOODS RICH IN CALCIUM AND PHOSPHORUS

Foodstuff	Calcium mg./100g.	Phosphorus mg./100g.	Foodstuff	Calcium mg./100g.	Phosphorus mg./100g.
Cheese (ave.)	800	450	Currants (dried)	95	40
Milk (whole)	120	95	,, (black, raw)	60	43
Egg (whole)	60	218	,, (red, raw)	35	29
Fish	40	200	Dates (dried)	68	64
Herring	100	272	Figs (dried)	284	91
Apricots (dried)	92	118	Lemons (whole)	107	20
,, (fresh)	17	21	Beans, butter (raw)	85	318
Blackberries	63	23	,, haricot (raw)	180	309
Oranges	41	24	Watercress	222	127
Prunes	38	83	Mustard and cress	66	65
Rhubarb (raw)	103	21	Kale	200	60
Sultanas (dried)	52	94	Treacle (black)	495	30
Almonds	247	442	Sardines (oil)	400	—

Calcium therapy demands an adequate amount of vitamin D. If milk cannot be taken, the oral administration of calcium is the best for all practical purposes. It is wise to note that the administration of excess calcium without a supply of vitamin D is likely to do more harm than good. The rational method is to give about 0·5 gram with 1000 to 5000 international units of vitamin D depending upon whether the vitamin D is required for prophylaxis or for treatment.

In pregnancy calcium plays a very important part. At birth the child's body is a veritable reservoir of calcium; the body of an average baby may contain about 30 grams of calcium, all of which is held in reserve because of the comparative lack in the maternal supply (0·03 g. per cent) of this important element. Cow's milk contains 0·12 g. per cent of calcium.

In dealing with mineral requirements, as always, availability must be considered. Milk and milk products, because of their predominance in dietaries, supply the greater part of the daily calcium and phosphorus requirements. Vegetables must not be neglected. The availability of calcium is excellent in beans, cauliflower, cabbage, broccoli and kale. Spinach, despite its large content of calcium, cannot be regarded as a good source of this element because of the presence of oxalic acid. Rhubarb is also equally doubtful in this respect.

Fish and meat of all kinds are excellent sources of these minerals. Nuts also have a rich content but the availability of the mineral salts in them is probably limited.

Iron.—Iron is that constituent of hæmoglobin upon which the carriage of oxygen depends. The hæmoglobin is found in the red corpuscles of which there are many millions in the blood. By means of these blood cells, oxygen is carried to every part of the body and there transferred to the tissue cells, many of which also contain minute amounts of iron in their structure. It is rather surprising that so important an element as iron should be found in comparatively small amounts in our foodstuffs. Iron absorbed from the intestine is stored to a limited extent in the liver, bone marrow and the spleen. So limited, however, are the stores of iron in the adult body that, to make good any loss of the element, there should always be an adequate supply of iron in the diet. In men, the normal loss of iron is very small, just as the amount utilized day by day is small, nevertheless, in view of its importance in oxidative processes within the body, the optimal requirement must constantly be maintained. This presents no dietary difficulty. In women, however, menstruation is responsible for very definite losses of iron, and in pregnancy, particularly in the latter half, many women have a low blood hæmoglobin. This can be overcome by diet, if necessary aided by medical treatment.

Iron Requirements of Adults and Children.—The iron requirement of adults is 12 mg. per day ; for children it varies from 6 mg. at 1 year to 12 mg. at 12 years ; for adolescents and pregnant and nursing mothers it is 15 to 20 mg. per day. The iron requirement of normal adults is well cared for if an adequate mixed diet be taken, that of children and nursing mothers requires some comment.

The child at birth has a large store of iron in its body, mainly

in the liver, which should serve as an iron reserve during lactation. It was Bunge who, many years ago, was responsible for the statement that at birth the child's body contained a store of available iron sufficient to supply its need for iron throughout the period of lactation. In 1933 Ramage and others estimated the amount of iron in the human embryonic liver. They found that during the latter half of pregnancy the total iron content of the liver of the fœtus rose from approximately 15 mg. to 75 mg. The rate of depletion of this iron reserve in the infant depends upon the degree of prenatal storing, the amount of iron in the mother's milk, and the degree of breakdown of superfluous red blood cells by which iron is released. It was usual in the past to regard a fall in the hæmoglobin of the blood during the first six months of life as normal, but it has been proved that the recovery from the so-called ' normal ' fall of hæmoglobin in the second and third month is more rapid and the level of hæmoglobin better maintained if the child be given egg-yolk from the third or fourth month. The addition of iron to the infant's diet, either as egg-yolk or as a ferrous salt, helps to develop children, heavier and more robust, than those who are allowed to suffer a diminution in the hæmoglobin content of their blood. The iron requirement up to $1\frac{1}{2}$ years is not less than 0·5 gram per kilogram of body weight.

Hæmoglobin Levels as evidence of the Nutritional State.—Nutritional deficiency of children as well as of pregnant and non-pregnant women can be assessed by determining the hæmoglobin concentration of the blood. The standard for hæmoglobin estimation is 13·8 g. Hb. per 100 c.c. of blood equalling 100 per cent. At the request of the Ministry of Health, the Medical Research Council undertook to obtain evidence of the nutritional state of the people of this country in the *fourth year* of war. A special committee considered the problem from dietary, medical, sociological and psychological aspects. It was previously realized that a long-continued iron deficiency could adversely affect the protein content of the blood. They therefore investigated hæmoglobin and protein levels in the blood of 13,000 adults and 3000 children and compared the results with those obtained before and during the war. They concluded " that in group studies the incidence of anæmia had not increased but that there was still an undue amount of preventable anæmia which may be due to lack of hæmopoetic

factors, especially iron in the diet ". The anæmia was found particularly in infants and young children, pregnant women, housewives and certain occupational groups. Comparing the results of blood protein estimations on home blood donors with those obtained from Canadian soldiers, they found a significantly higher figure for the Canadian soldier which, in their opinion, was due to the higher animal protein intake in the military diets. The committee concluded : " An effort should be made to reduce the considerable proportion of low levels of hæmoglobin which some groups still reveal—e.g. young children, pregnant women, and persons at the lower economic level." Professor Stanley Davidson, of Edinburgh, is of the opinion that the national bread, with its higher iron content, was largely responsible for the rise in the hæmoglobin content in infants and school children during 1943–44. Dr. Helen Mackay of the Queen Elizabeth Hospital for Children, London, while not accepting the national loaf as the one and only factor, agrees that the reduction in the incidence of anæmia in children is due to an improvement in diet. Both authorities agree that anæmia in children is still extremely common and that the best therapeutic results are obtained by giving the children an iron preparation. The preparation used in these experiments was 3 grains of ferrous sulphate or the preparation Fersolate (Glaxo), which is a pill containing 4 grains of ferrous sulphate, with small amounts of copper and manganese. An interesting scientific point is that copper, an element present in very small amounts in the body as well as in foodstuffs, is of value in stimulating the utilization of iron and the production of hæmoglobin, the complex oxygen-carrying compound found in the red blood cells.

Nutritional Anæmia.—Two types of anæmia are of nutritional interest : (*a*) the hypochromic in which there is a deficiency of hæmoglobin and therefore of iron in the red blood corpuscles ; (*b*) that in which there is a marked failure in the bone marrow to develop red blood corpuscles.

[a] **Hypochromic Anæmia.**—Many years ago it was noted that mice fed on a diet consisting solely of milk developed a type of anæmia, recovery from which could be obtained only on the addition of egg-yolk to the diet. This fact is the basis of all scientific work which has shown that recovery from a condition of anæmia, characterized by a loss of hæmoglobin

from the red blood cells, is dependent upon a normal amount of protein, iron and copper in the blood. This type of anæmia is called hypochromic because of the lack of the iron-containing pigment—hæmoglobin—in the blood corpuscles. Associated with this condition, and by some believed to be a causative factor, is a failure of gastric function due to a deficiency of hydrochloric acid in the gastric juice. The diets of patients showing this type of anæmia are often deficient in animal protein (e.g. milk, eggs), and vegetables. In hypochromic anæmia there is no evidence that any specific substance necessary for the formation of hæmoglobin is lacking from the gastric juice. It would appear then, that nutritional anæmia is due in the first place to a lack of iron in the diet and in the second to a lack of hydrochloric acid in the stomach, where the mineral acid is necessary for the liberation of iron from the food and its transference from the ferric to the ferrous state. This type of anæmia is found in infants over six months of age, and also in women as a result of iron loss during menstruation.

[**b**] **Pernicious Anæmia.**—In this type of anæmia there is a marked diminution in the number of red blood corpuscles in the circulating blood. Quite a few of these corpuscles are much larger than normal, hence the term macrocytic anæmia and both types of cell have more than their normal supply of hæmoglobin. It is well known that bone marrow, in order to function normally in the production of red blood cells, must receive from the liver, a substance called the "hæmatinic principle". This substance, which is stored in the liver, was discovered by Minot and Murphy in the U.S.A. in 1926. It depends upon two factors for its formation, one, the intrinsic factor, in the mucosa of the stomach, the other, the extrinsic factor of Castle, supplied by the food; the chief sources of this latter factor, the chemical nature of which is not yet known (? folic acid), are beef, rice polishings, marmite and wheat germ.

In a recent paper by Taylor and Chhuttani (1945) the relationship between animal protein and macrocytic anæmia has been demonstrated in Indian subjects living on meat and vegetarian diets. The tropical macrocytic anæmia, found only in the vegetarian group, was present when milk, fresh fruit and vegetables were all much reduced in a vegetarian diet. The meat eaters suffered from the hypochromic type of anæmia. In the groups examined the incidence of severe anæmia was

very much greater in vegetarians than in meat eaters. The investigators noted accurately the dietary intake of the two groups and concluded that " the anæmia, in its type and severity, was closely and regularly related to the diet consumed ". The evidence presented clearly indicates that a nutritional anæmia in children and women exists in this country. With meat and liver in short supply (1945) it is not easy to ensure the best diet possible to prevent anæmia in pregnant or nursing mothers and in growing children. The public must be educated to the importance of the need of mothers and children for their fair share of meat in the family dietary. To combat the deficiency in iron for these vulnerable groups, the infant should receive, if artificially fed, iron incorporated in dried milk, meat as mince from six months onwards and iron in liquid form. The Department of Health for Scotland suggests that an iron mixture should be given to babies whether breast or bottle fed. According to Mackay and Goodfellow there is one foodstuff which can produce a rapid cure of nutritional anæmia in children over one year, and that is liver in daily amounts of 4 oz.; this supplies 16 mg. of iron. This statement was made in 1931; while the iron content of liver has not appreciably changed since then, its cost and supply unfortunately have!

Iron Content of Foods.—With the estimation of most minerals in foods it is essential to use those figures which state the available amounts. The availability of iron varies in different foods, but iron is absorbed from the alimentary tract only when it is required to replenish that which is lost from the blood and tissues. Some foods contain large amounts of phytic acid, such as nuts, haricot beans and oatmeal, and when these form a substantial part of the diet, iron, which becomes available in the intestine, may be bound by the phytic acid and thus lost to the body. With a mixed and adequate diet so much iron is taken that the fear of loss by phytic acid containing foods, except in the case of young children, and women in the lower income groups, may be disregarded. The foods which are good sources of iron are shown in Table 16.

Iodine.—The indispensability of iodine in nutrition is unquestioned. It is required by the thyroid gland for the production of its active principle, thyroxine. When there is a deficiency of iodine due to its lack in food or in water, the thyroid gland becomes enlarged giving rise to the condition

known as goitre. Where the thyroid function declines in adults, a condition known as myxœdema appears. In myxœdema the

TABLE 16

THE IRON CONTENT OF CERTAIN FOODS. *COMPILED FROM "NUTRITIVE VALUES OF WAR-TIME FOODS"*, M.R.C., 1945 AND "*CHEMICAL COMPOSITION OF FOODS*", McCANCE AND WIDDOWSON, 1940

Food	Iron Content		Available Iron as a Percentage of the Total
	mg./oz.	mg./100 g.	
Liver, calf (raw)	3·9	13·9	100
,, ox	3·9	13·9	89
Corned beef	3·1	11·0	35
Kidney	3·8	13·4	66
Beef	1·0	4·0	29
Eggs, fresh	0·7	3·0	100
,, dried	3·1	11·0	—
Bread, brown, 1943, unfortified	0·6	2·1	90
,, national, 1945, 80 % extraction	0·5	1·2	—
Bread, white	0·2	0·7	89
Oatmeal	1·2	4·1	96
Lentils	2·2	7·6	66
Haricot beans	1·9	6·7	83
Kale	0·5	1·8	—
Figs (dried)	1·2	4·2	96
Prunes (dried)	0·8	2·9	72
Raisins (dried)	0·5	1·6	96
Blackberries (fresh)	0·9	0·3	40
Cranberries	0·3	1·1	70
Currants (black)	0·4	1·3	100
,, (red)	0·3	1·2	85
Loganberries	0·4	1·4	76
Raspberries	0·3	1·2	76
Treacle (black)	2·6	9·2	100
Chocolate (plain)	0·9	3·3	89
Cocoa	4·1	14·3	93

Note.—In reading such tables one should take notice of the amount of the food usually eaten.

basal metabolism is reduced, the subject becomes slow both mentally and physically, the hair loses its lustre and falls out, the skin becomes dry and immobile, and obesity results. All these signs disappear following the administration of potassium

iodide, thyroxine or extract of the thyroid gland. The transformations which can be effected by treatment are in many cases dramatic (Fig. 10). Children who suffer from a failure in the embryonic development of the thyroid gland are stunted in growth, extremely ugly in appearance and often imbecilic. These children are called cretins, and if treated early in life by continuous administration of thyroxine, they can be almost magically transformed (see Fig. 11).

Goitre is endemic in many parts of the world, e.g. the Himalayan regions of India, certain parts of the N.W. territories of the U.S.A., in New Zealand, Switzerland and the United Kingdom. It is generally attributed to a lack of iodine in river water. The sea is the great source of iodine. The amount of iodine in rivers depends upon the geological formation of the country through which they run. In mountainous regions and in the plains supplied by glacial water, and also in certain lake regions, iodine is deficient in the water and the soil. All who live in, or obtain their domestic water from such areas will suffer from iodine lack, and the meat and milk of cows and goats in these areas will also be lacking in this most valuable element. A considerable amount of evidence has been obtained about the deficiency in iodine of certain of the rivers of Great Britain. In the areas supplied by these rivers a definite incidence has been recorded of enlarged thyroid and also of goitre in boys and girls between 11 and 18 years of age. Working on records of the Board of Education Goitre Survey of 1924 Dr. Stocks found goitre markedly prevalent in North Oxfordshire where the iodine content of the water was stated to be 1·4 to 3·0 μg. per litre. In the southern area of Oxfordshire and in Windsor in Berkshire, the iodine content of the water supply was 10 to 52 μg. per litre, and no evidence of endemic goitre was found. Miss B. W. Simpson of the Iodine Laboratory, Rowett Research Institute, has examined samples of drinking water from Cornwall to Caithness and her results have been correlated with the clinical evidence of hyperplastic or enlarged thyroid in many of the river areas examined. The areas of high incidence in England are Cornwall, Devon, Somerset and Oxfordshire in the South-west, Derbyshire and Cheshire in the Midlands, the Isle of Wight in the South and Durham and Northumberland in the North. In Scotland two areas are prominent. Inverness-shire and Dumfriesshire. In certain of these areas, such as

FIG. 10.—Myxœdema treated for thirty years with thyroid. A, aged 65, before treatment. B, five weeks later. C, fifteen months later. D, aged 94. [*After Raven, by courtesy Brit. Med. Jnl.*]

[*To face page* 100.

A B

Fig. 11.—A. A cretin 23 months old. B. The same child, 34 months old, after administration of sheep's thyroids for 11 months. [*After Osler, by courtesy of Messrs. J. & A. Churchill, Ltd.*]

[*To face page* 101.

Somerset and Derbyshire, the incidence of goitre has been reduced, due to extensive alterations in their water supplies. The incidence is of the order of 10 to 30 per cent in girls of 15 to 17 years and approximately a third of those figures for boys of the same age. It must be emphasized that an enlarged thyroid gland does not imply an established goitre. The aim of the investigations being carried out by the Medical Research Council is the elimination of goitre and " the control of those forms of mental and physical degeneracy, such as cretinism, mutism and idiocy, which are dependent upon thyroid insufficiency ". Goitre is due to a combination of factors, chief among which is the part played by calcium, magnesium and fluorine in reducing the availability of iodine.

The treatment of goitre, due to a deficiency of the hormone or active principle of the thyroid gland, is essentially a nutritional problem. Thyroid gland of the sheep was first administered for the treatment of myxœdema in this country by Dr. Murray in 1891. To-day dried thyroid or thyroxine is given. The discovery, by Baumann in 1895, of iodine in the thyroid gland and its isolation from thyroxine by Kendall in 1914, led to the idea that potassium iodide may be a remedy for goitre in children. The idea was acted upon. The most successful of the early experiments in the iodide treatment of goitre in children took place in Switzerland in 1918 by Professor Klinger of Zurich and in the State of Ohio in U.S.A. in 1917 under the supervision of Drs. Marine and Kimball. In Switzerland the incidence of goitre in school children in three Cantons examined fell in three years from 87 to 13 per cent. In the State of Ohio 5 milligrams of potassium iodide were given twice weekly for one month and repeated six-monthly from 1917 to 1920. In an area where the incidence of goitre in school children was approximately 50 per cent, of 2000 taking the salt only 5 had enlarged thyroids, while of 2000 untreated children 500 showed symptoms and signs of thyroid enlargement. Modern prophylactic treatment is carried out in many countries, including Switzerland, Poland and the U.S.A., by the use of iodized table salt, containing 10 milligrams of potassium iodide per kilogram of salt. It is recommended by the Medical Research Council that a similar measure should be adopted in this country.

The treatment of school children in goitrous areas, under medical or school supervision has been productive of excellent

results, but supervision must always be exercised in such treatment in order to prevent the administration of iodine to adolescents who may be prone to excessive activity of the thyroid gland.

Human Requirements.—Iodine, a trace element, is essential for human nutrition, in amounts which are not precisely known. It is stated that 50 μg./day are required. More important at present is it to realize the need of children and pregnant women for this element and if in a goitre area to treat accordingly.

Foods most noted as sources of iodine are : fish, milk, leafy vegetables, potatoes and carrots. Seaweed contains up to 10 mg. per 100 grams ; fish 0·01 mg. per 100 grams.

That all these elements are of extreme value in reproduction is seen by comparing the results of feeding defective mineral foodstuffs to normal animals.

The Utilization of Mineral Salts.—Utilization depends upon absorption by the intestinal mucous membrane. A lack of any mineral in the body may be due to a dietary deficiency or a faulty absorption of the mineral in question. A faulty absorption of any element cannot generally be improved merely by increased ingestion of the mineral salt. Mineral salts do not need to be broken up by digestive processes, but in foods they are often in combination with proteins, fats and carbohydrates, so that the food has to be thoroughly digested in order to free the mineral salts for absorption. The facility with which the salts are taken up during digestion depends upon the type of food in which they are presented to the body, e.g. the calcium of milk is far better absorbed than that of vegetables ; the mineral elements in egg-yolk are well absorbed ; iron is better absorbed in solution than in the form of an insoluble compound. It is rather important that fat digestion should be normal if the minerals are to be absorbed in their correct proportions ; any inability to assimilate fats should indicate that, unless steps are taken to correct the disability, or, fatty substances are reduced in the diet, there will undoubtedly be some loss of mineral elements from the body. Important points in this respect are the balance between base-forming (sodium, potassium, calcium, etc.) and acid-forming elements (sulphur, phosphorus, chlorine, etc.). An excellent example of this is afforded by calcium and phosphorus : normal utilization of these two elements is secured when they are in the

ratio of 1 : 1 in the food taken. This is approximately the ratio of calcium to phosphorus in milk. Again, iron utilization has been shown to be improved by taking foods rich in calcium, such as milk. In this connection vitamins play a part : vitamin D, for instance, is necessary for the maintenance of the correct percentage of calcium and phosphorus in the blood and the utilization of these elements in the formation of strong bones and teeth. One of the most important factors in preventing a normal absorption of iron is intestinal putrefaction arising from faulty protein digestion. It is clear, then, that for the best utilization of mineral salts, the alimentary tract must be in order, and the diet should contain liberal amounts of milk, and of those fruits and vegetables which are rich in vitamins.

Of the elements mentioned, only four are at all likely to be deficient in average diets ; these are calcium, phosphorus, iron and iodine, and of these four, the one usually found most deficient is calcium. According to some authorities 50 per cent of our population suffer from calcium deficiency. The distribution of the minerals, calcium, phosphorus and iron, in foods will be seen in Table 17.

Calcium.—The first point of note with regard to calcium is its uneven distribution in all foods with the exception of milk and milk products. Milk and cheese form the crux of the problem of calcium supply. Generally vegetables, fruits and whole grains are satisfactory sources of calcium ; but meat, fish, sugar, fat and highly-milled cereals are definitely lacking in this element.

Phosphorus.—It is interesting to note that, with few exceptions, our foodstuffs are excellent sources of phosphorus, the best being cheese, vegetables, meats, eggs and whole grains. The exceptions are butter and sugar, which contain none.

Iron.—This element is conspicuous by its absence in most foods. It is not found in butter, vegetable oils and sugar ; it is found in very small amounts in fish and milk. Certain cheeses contain iron, others do not. Most vegetables are good sources, but the best are egg-yolk, liver, whole grains, lentils, beans, kale, peas and certain fruits.

Iodine.—This mineral, found in the body and in foods in such extremely small amounts and so vitally important for physical and mental health, is to be found in codfish, salmon, indeed all fish, cod-liver oil, milk and leafy vegetables.

It is usual and indeed necessary in supplying mineral salts to go well beyond the needs of the body. To double the requirements would be a wise procedure in view of the various factors which tend to hinder the assimilation of the mineral salts. We may sum up what has been said on the supply of mineral salts as follows :—

Milk should form the basis of the diet. Adults should take a half to one pint per day ; children up to 14 years, 2 pints per day. Fruit and vegetables should be taken liberally, and if these are not freely available more wholemeal bread and whole grain cereals should be taken. The importance of eggs and the outstanding value of certain cheeses should not be overlooked.

TABLE 17

FOODS RICH IN MINERALS

Calcium	Phosphorus	Iron	Iodine
Cheese	Cheese	Liver	Fish
Milk	Egg-yolk	Egg-yolk	Crab, lobster and oysters
Egg-yolk	Fish	Treacle (black)	
Treacle (black)	Whole grains	Lentils	
Kale		Meat	

Foods deficient or lacking in mineral salts are : butter, sugars, honey, white flour, orange and grape juice, highly purified starches.

Base-Forming Elements	Acid-Forming Elements
Sodium	Chlorine
Potassium	Sulphur
Calcium	Phosphorus
Magnesium	Carbon
Iron	

ACIDITY AND ALKALINITY OF FOODS DETERMINED BY THE REACTION OF THE ASH

Acid	Alkaline
Meat	Milk
Fish	Fruit juices (most)
Eggs	Peas
Cheese	Beans
Cereals	Root vegetables

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CHAPTER IX

VITAMINS AND DIETARY DEFICIENCY DISEASES

VITAMIN A AND THE VITAMIN B COMPLEX

THE history of the development of our knowledge of vitamins forms one of the most interesting stories of scientific research. The first investigations which indicated or merely hinted at the possibility of unknown and indispensable substances necessary for the maintenance of health date as far back as 1881. In 1910 Sir Frederick Gowland Hopkins of Cambridge University called these unknown substances " accessory food factors ". During the past twenty years an enormous amount of research work has been carried out in isolating these factors, in determining their chemical structure and in demonstrating the parts they play in maintaining health and in promoting growth. The most recent work has led us into a veritable maze of chemical formulæ and shown us the most undreamt of relations between factors apparently so far apart as those which give life and those which destroy it, namely those chemical agencies which determine reproduction of the species and those chemical substances which produce cancer.

In 1912 Osborne and Mendel in America showed that rats fed on an artificial protein-free milk, i.e. a solution containing all the constituents of milk with the exception of protein (i.e. purified sugar, fat and mineral salts), failed to maintain growth. The interest in such dietary studies had been inspired by the work of a Dutch military doctor in the Dutch East Indies, who later became Professor of Hygiene at Utrecht. This was Dr. Christian Eijkman, who, in 1897, came to the conclusion that the disease known as beri-beri resulted from the continuous consumption of polished rice. He had noticed in his official routine survey of prisons in Java that birds (pigeons, fowls, ducks, etc.) when fed upon polished rice developed a disease which he called " polyneuritis gallinarum ", because of its resemblance to human beri-beri. Further, he made the notable observation that the birds, if fed on unpolished rice, i.e. rice with the pericarp intact, did not develop the disease.

Hopkins showed that rats did not grow if given a purified diet of caseinogen (milk protein), starch, salts and lard, but did grow to full size if 3 c.c. (approx. 1/10 oz.) of milk were added daily to such a diet (Fig. 12). Three cubic centimetres of milk contain 0·08 gram of solids, of which the greater part

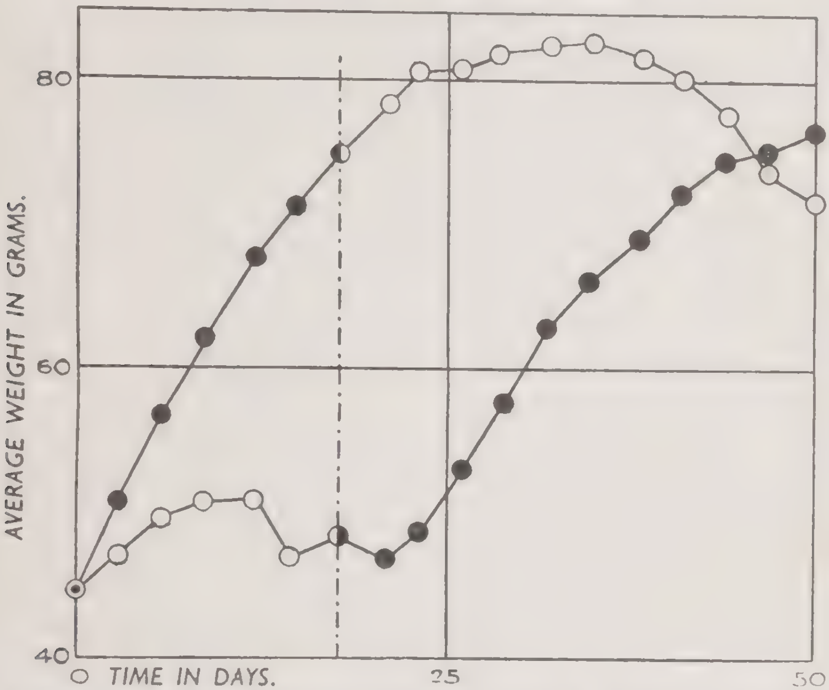

Fig. 12.—Two curves showing growth of rats with and without " Vitamin A". Lower curve (up to 18th day), eight male rats on pure dietary ; upper curve, eight similar rats taking 3 c.c. of milk each a day. On the 18th day, marked by vertical dotted line, the milk was transferred from one set to the other. [*Sir Frederick G. Hopkins.*]

is already present in the artificial diet. This led to the discovery of a vitamin, soluble in milk fat, to which the name " fat soluble vitamin A " was given. McCollum and Davis, in 1915, found that rats fed on a synthetic diet, containing butter fat to supply the fat soluble vitamin, did not grow satisfactorily, and that they required another factor, which they named " water soluble vitamin B ". Before long, experiments had made it necessary to differentiate two factors in the complex called vitamin B, namely B_1, a vitamin which prevented polyneuritis in birds, and B_2, a vitamin discovered by Goldberger and others in U.S.A. in 1926, and found to be of value in preventing a certain type of dermatitis in rats and the skin

disease, pellagra, in man. And so was introduced the alphabetical nomenclature of vitamins. Some 16 or 17 vitamins have been distinguished according to their different properties and mode of action.

VITAMIN A (Axerophthol)

This is one of the fat soluble vitamins which is found in food associated with animal fats, but not with lard and vegetable fats, and also with the green and yellow pigments of plants. Vitamin A is partially manufactured in the animal body from the yellow pigment carotene which is present in land and marine plants. It forms the colouring matter of carrots, and is present in the green primitive plants which are to be found in all oceans. Animals and fish eat these plants, make the vitamin from carotene and store it in the liver and body fats. This is especially true of fish ; the older the fish the richer is their store of vitamin A.

One of the functions of vitamin A is to promote the growth and development of the body. A study of the growth curve of rats fed on diets with and without vitamin A clearly shows the part played by the vitamin in respect of growth. When a rat, previously fed on an adequate diet, is given a diet adequate in all respects except for vitamin A, it continues to grow for about four weeks depending upon the amount of vitamin A stored in the body. Upon depletion of this store, there is a dramatic fall in weight. If, when this has become manifest, vitamin A be added to the diet in the pure form or as butter fat or egg-yolk, the weight curve is rapidly restored to normal (Fig. 13). If this is not done, death will rapidly ensue. It was in the course of such experiments that other signs of vitamin A deficiency were noticed. Characteristic eye trouble always developed ; the lachrymal gland no longer secreted tears, the conjunctiva of the eyeball became dry and conjunctivitis developed leading to swollen and inflamed eyelids. With further development of the deficiency the cornea of the eye may become thickened and opaque leading to blindness. Several diseases of the eye mentioned in the ancient medical literature of China, Arabia and Egypt were undoubtedly due to vitamin A deficiency. If young children and young animals are fed over long periods on diets insufficient in vitamin A, they cease to grow, suffer from night blindness and an infective

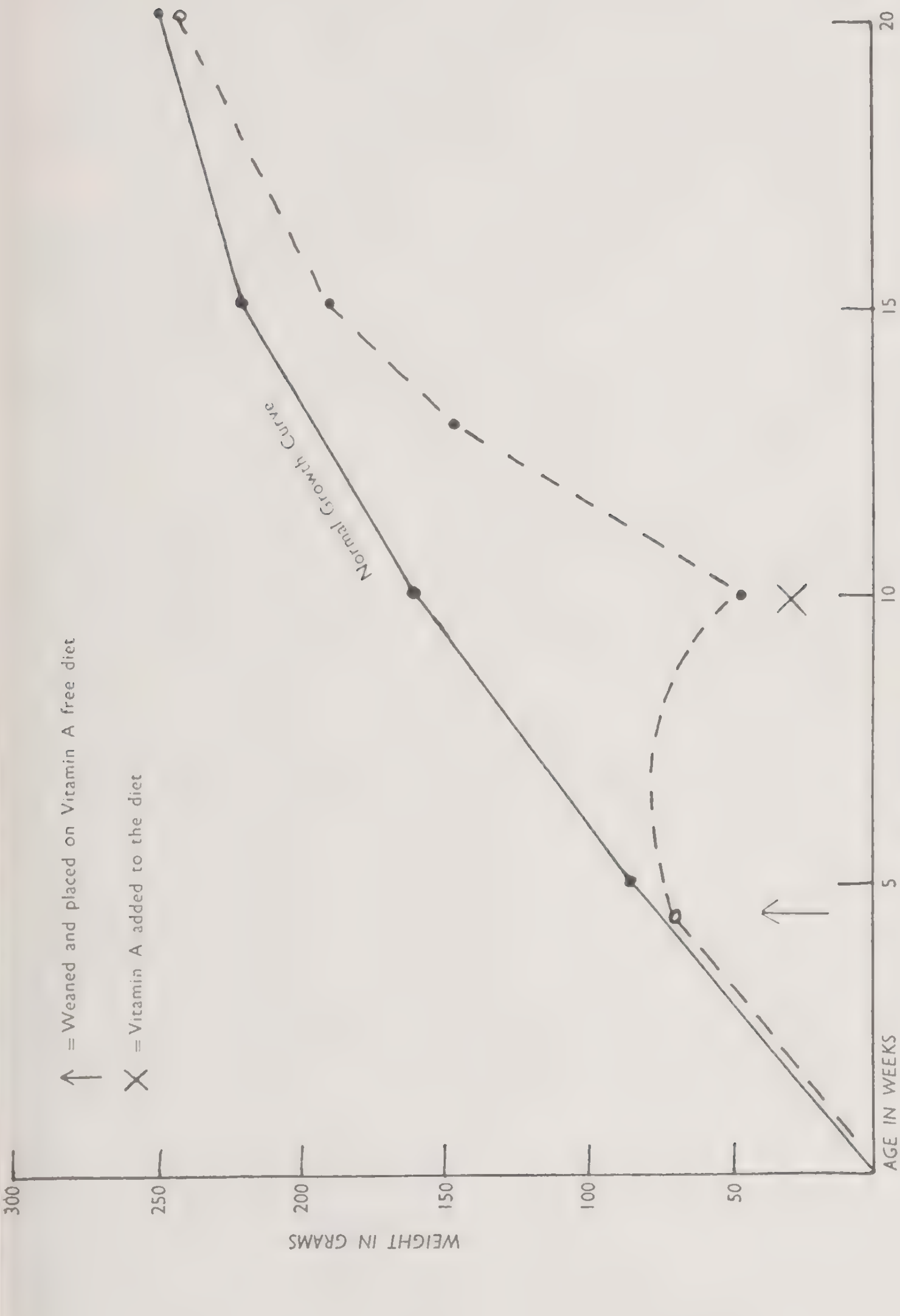

FIG. 13.—Effect of vitamin A on growth in the rat.

condition of the eyes known as xerophthalmia (Gk. xeros = dry, ophthalmos = the eye). This latter condition may lead to distinctive invasion of the cornea with opacities. This is called keratomalacia. Xerophthalmia is characterized by swelling and thickening of the cornea and conjunctivitis. It will respond to no treatment which does not include vitamin A (Fig. 14). It was quite common in Denmark during the Great War, 1914–18, when the Danes substituted margarine for butter which they sold to Germany and other countries at no small profit.

Night blindness has been observed in endemic form in many parts of the world. Experiments on rats have shown that this disease is one affecting the protective visual purple in the retina of the eye. Rats on a vitamin A deficiency diet, placed in the dark after a definite time exposure to bright light show a subnormal regeneration of their visual purple. This can be tested by noting the ability of the rats to jump from a table into a cage in a dim light after exposure to bright sunlight or any bright light. The abnormal rats fail to see the edge of the table and fall to the floor. In one hour after giving them vitamin A they can spring into the cage as quickly as their normal fellows. This form of night blindness was quite common during the Great War (1914–18) among Austrian prisoners of war in Russia, and was studied by various Austrian physicians, themselves prisoners. They found the disorder to be a frequent one amongst Russian peasants in peace time, especially during the period of religious fasting before Easter. During this period all animal foods were forbidden, including fish, eggs, milk and butter; the diet enjoined was strictly vegetarian, and included fats and oils of vegetable origin only. Lightly-cooked liver or cod-liver oil were the popular remedies. One observer found that the disease could be cured in about 4 days by giving cod-liver oil for 2 or 3 days, another by giving 3 eggs daily for 3 days. Night blindness is also known in Newfoundland where, because of poverty and a poor consumption of fresh fish, most of the fish being salted or cured, not only night blindness is prevalent, but beri-beri. During the earlier months of the world war (1939–45) considerable interest was aroused in the question of the relationship between vitamin A intake and dark adaptation. It is maintained by many that while such a relation exists, the dark adaptation test cannot be accepted as entirely reliable for the diagnosis of vitamin A

deficiency. This opinion, however, is not supported by Sinclair and his co-workers of the Oxford Nutrition Survey. The black-out conditions obtaining during the war have been ideal for

TABLE 18

VITAMIN A IN FOODS

I.U. per 100 *grams.*

	Edible portion	As purchased
Butter	4,000	4,000
Margarine (vitaminised)	2,000	2,000
Milk, summer	140	140
,, winter	70	70
,, condensed	370	
,, human	300	
Egg, whole	1,000	880
,, yolk	3,000	3,000
Cheese, cheddar	1,300	1,300
Carrots (*c*)	10,000	9,500 (5%)
,, (*c*) (Sept.)	20,000	16,000 (20%)
Parsley (*c*)	13,000	13,000
Turnip tops (*c*)	10,000	7,500 (25%)
Watercress (*c*)	5,000	4,250 (15%)
Spinach (*c*)	13,000	9,750 (25%)
Cabbage (*c*)	900	630
Tomatoes (*c*)	3,000	2,550 (15%)
Halibut liver oil	5,000,000	5,000,000
Cod liver oil (M. of Food)	100,000	100,000
Liver, calf	4,000	4,000
,, ox	15,000	15,000
,, pig	5,000	5,000
,, sheep	45,000	45,000
Apricots (dried)	5,000	5,000
Prunes (dried)	2,500	2,500

c = carotene.

Note.—The figures in brackets represent the percentage wastage in the food-stuff as bought. See Table of vitamin C foods.

detecting clinical abnormalities in dark adaptation, yet from centres so far apart as Aberdeen and Chicago the statement is forthcoming that " a deficiency of this vitamin is not common ".

Source of Vitamin A.—Vitamin A is found in fats of animal origin,—milk, cream, butter, egg-yolk and liver. The most important source is fish liver oil, because the organism stores most of the excess of vitamin A in the liver. It is not found in vegetable oils, e.g. linseed oil, olive oil. Fish either derive their vitamin A from marine algæ or make it themselves: the latter theory is the more probable, since fish and mammals form their own type of vitamin A from ingested precursors of the vitamin. Vegetable leaves which turn green are good sources of the vitamin. Green vegetables and carrots do not contain vitamin A but its precursor carotene.

The vitamin A content of foods is expressed in International Units (I.U.). One international unit of vitamin A = 0·6 μg. (micrograms) or 0·0006 mg. of beta-carotene which is equivalent in activity to 0·33 μg. of pure vitamin A. Children and pregnant women require relatively more vitamin A than adults. According to accepted standards an adult should receive 4000 I.U. daily; a child of 1 year 1200 I.U., adolescents 4000 to 5000 I.U. During the latter half of pregnancy and lactation the requirement is 5000 and 6000 I.U. per day respectively. From the results of recent dietary surveys, these figures should be regarded as optimal. It may be safe to say that a diet could be regarded as adequate if it supplied 60 I.U. of vitamin A per kg. of body weight daily for adults, and 80 I.U. per kg. of body weight for nursing mothers.

Variations in the vitamin A value of dairy produce result from seasonal changes in the feeding of farm stock, which means that the vitamin A content of milk, butter and eggs is lowest at the end of the winter season and highest during the summer and autumn. To prevent deficiencies in children's dietaries the best and most reliable method is to give any liver-oil preparation. Cod-liver oil, which of all liver oil preparations is the most largely produced in this country, and halibut liver oil are the best supplementary sources of this vitamin.

THE VITAMIN B COMPLEX

In the first volume of the *Lancet* of 1906 there is an article on "The Preservation of the health of the personnel of the Japanese Navy and Army," written by Takaki, Director of the Medical Department of the Japanese Navy. Having, as a

young naval officer, noted the curse of beri-beri in the naval service, he came to St. Thomas' Hospital, London, in 1875 to enlarge his knowledge of medicine and to note conditions in European navies where beri-beri was unknown. Beri-beri, a disease marked by muscular wasting and paralysis of the legs, is very prevalent in China and India, and is not unknown in Norway and Newfoundland. Believing that he was faced with a dietary deficiency and not an infectious disease, Takaki was successful in reducing the mortality in the Japanese Navy by the simple expedient of changing the diet. The experiment which led him to do this was carried out in 1882 upon the crews of two training ships. The first vessel sailed from Japan to New Zealand, South America and Honolulu making the voyage in 272 days. There were 169 cases of beri-beri and 25 deaths in a crew of 276 men. The second vessel repeated the same journey taking 287 days. There were 14 cases of beri-beri and no deaths. The change in diet amounted to an increase in rice of 5 oz., vegetables 3 oz., meat 2 oz. and an unspecified amount of condensed milk. Subsequently, and with very excellent results, a new dietary was introduced into the Japanese Navy; rice was decreased, vegetables increased, wheat and bread and $1\frac{1}{4}$ pints of milk daily were added. In 1897 Eijkman, a Dutch physician, had demonstrated on men and fowls that beri-beri, as also its equivalent in fowls, was a dietary deficiency disease and capable of cure by simply adding rice polishings to the diet. Numerous experiments by British and American army medical officers in the East further proved that beri-beri could be prevented by having unpolished rice or a sufficiency of beans in the diet. Reference will be made later to the part played by beri-beri amongst British troops during the siege of Kut-el-Amara in 1917.

The first idea that a water soluble food factor, present in milk and certain vegetables, may be responsible for the restoration of growth following the steady decline produced by a diet of purified proteins, carbohydrates, fats and mineral salts came from Sir Frederick Gowland Hopkins of Cambridge. The name "water soluble B" was given by McCollum in 1915 and was used by him to designate a single factor which could induce growth and cure polyneuritis in pigeons. In 1911 Funk crystallized a substance which, thinking he was dealing with an "amine structure", he called the "beri-beri vitamine".

As a result of much laborious research vitamin B_1 was isolated and ultimately structurally identified and synthesized by Williams and Cline in 1936. With the synthesis completed, vitamin B_1 became known in this country as aneurin and in U.S.A. as thiamin. For many years previously it had been known that what was called vitamin B consisted of two factors, one named B_1, an anti-neuritic factor, the other, B_2, a growth promoting factor When some six factors had been isolated, it was realized by investigators that the alphabetical terminology had served its day and now all vitamins, with the exception of vitamins A and D, are usually called by their official names, the chemical names which denote their structure being far too unwieldy for general use.

VITAMIN B_1 (Aneurin or Thiamin)

One of the first signs of vitamin B_1 deficiency is involvement of the nervous system. Many cases of neuritis in man have been cured by giving very small doses (10 mg.) of aneurin daily. The dramatic recovery from polyneuritis in birds following the addition of vitamin B_1 to the diet is shown in Figs. 15 and 16. Some extremely illuminating experiments have been performed by Professor Peters of Oxford. He it was who discovered that pigeons dying of polyneuritis had an increased amount of lactic acid in the brain, due to a failure to complete the oxidation of glucose. When aneurin was injected into these pigeons the lactic acid disappeared, proving that it was of importance in regulating the metabolism of carbohydrate. Another product of incomplete combustion of carbohydrate which accumulates in the blood of an animal suffering from an aneurin deficiency, is pyruvic acid. This causes a marked slowing in the frequency of the heart beat : in the rat it may be reduced from a normal frequency of 500 to 300 beats per minute. So dramatically is the normal frequency of beat restored by finely graduated doses of aneurin that Harris, also of Oxford, who is responsible for these facts, has used this as a test for the vitamin B_1 content of foods. In Fig. 17 is shown graphically the response of the slowed heart beat to white and whole grain bread, the latter being comparatively rich in vitamin B_1. The activity of the vitamin is also associated with the maintenance of tone in muscle, particularly the plain muscle of the stomach and

intestine. It will be readily realized that upon a normal tone of muscle depends that undefinable sense of well-being, which is often reflected in a good appetite. To what extent and in what manner aneurin, or any of the vitamins of the B complex, is related to these physiological and psychological events, it is still difficult to say. It has been said that "rats deprived of vitamin B possess no instinct which prompts them to select food containing this vitamin when a variety of foods is offered them". In the human sphere this would mean that we have

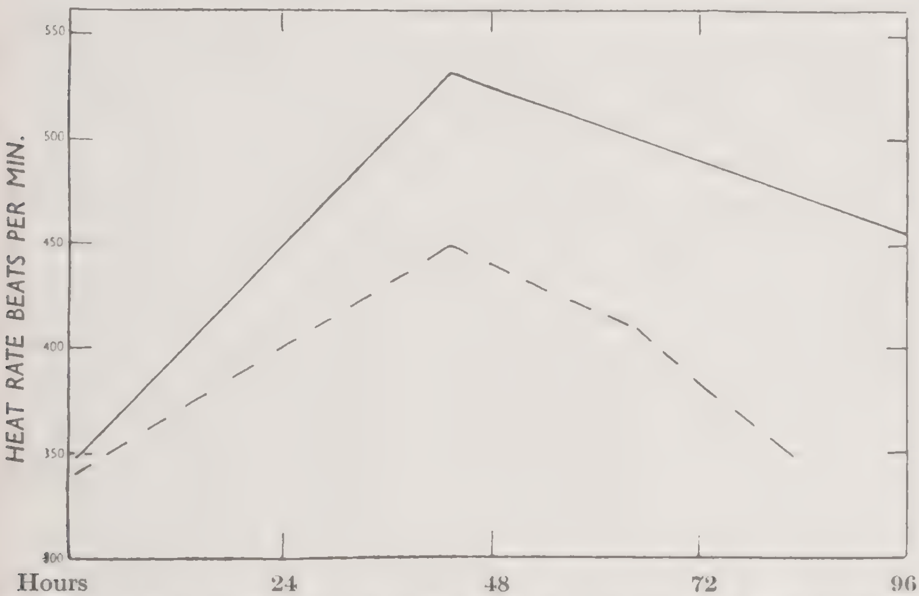

Fig. 17.—Effect of whole bread (vitamin B_1), and white on the heart rate (*Birch and Harris*).

no instinctive liking for the right kind of food. In contrast to this, however, must be placed the results of experiments by Professor Richter of Johns Hopkins University School, in which rats, amply provided with purified protein fat and carbohydrate, and with an array of 20 tubes containing in solution the essential mineral salts and vitamins, selected a diet perfectly suited to their needs. When the suprarenal glands, regulating salt metabolism, the pancreas, responsible for the digestion of protein, fats and carbohydrates and also, by insulin production, for the metabolism of carbohydrate, and the parathyroids, regulators of calcium metabolism, were individually removed, the rats quickly adjusted their selection of the

proffered foods to meet, as far as was possible, the new demands occasioned by the changes rather drastically thrust upon them.

But is the " instinct " which determines selection of the correct food, dependent upon the presence of vitamin B? It is well known how too much sugar in a dietary, or in children how too great a consumption of sweets and chocolate, will destroy the appetite, particularly the appetite which craves for wholesome food. A decrease in sugar tolerance, an increase in lactic and pyruvic acids in the blood and tissues, an impairment of appetite and a marked diminution of the activity of the intestine are all associated with vitamin B_1 deficiency. No one in such a bad physiological condition has ever been noted for his ability or even desire to practise any method of dietary selection. Gastro-intestinal disorders have increased with the departure from primitive food habits. The modern affliction, constipation, with most of its attendant ills, has been experimentally produced in animals and man and experimentally relieved, if not entirely cured, by adding to the diet those foods or foodstuffs which contain large amounts of aneurin, namely, wheat germ, whole grains, yeast extract, brewer's yeast concentrate, or by giving pure aneurin. These facts simply confirm the statement first made by Sir Robert McCarrison, I.M.S., that deficiency of " vitamin B_1 was responsible for many of the more common disturbances of the gastro-intestinal tract ".

A deprivation of this important food factor will cause a retardation in the growth of infants and young children. The failure to grow is, as may be imagined, coupled with loss of appetite and vigour. Numerous experiments with children have proved the value of aneurin. As an example of the type of experiment performed, mention may be made of one carried out on two groups of undernourished children, 11 to 13 years of age, one group given at the school lunch two rolls made of white flour, the other, two rolls made of flour containing equal parts of white flour and wheat germ. The average weight of the children at the commencement of the experiment was 88 lb. In 20 weeks the expected average weight according to Tables was $92\frac{1}{2}$ lb.; for the white flour group it was $90\frac{1}{2}$ lb., for the wheat germ group it was $95\frac{1}{2}$ lb.

With regard to the part played by vitamin B_1 in reproduction and lactation, the most striking comment comes from the East, namely, that women who have suffered severely from

beri-beri rarely, if ever, have children. Where, as in the Orient, vitamin B_1 deficiency is so common, it is not surprising to find a high infantile mortality and a high incidence of disease and physical unfitness amongst children and adolescents. Where dietary deficiencies are prevalent, there one often finds the vicious circle of early marriage and poor physical and mental development. Under conditions of a markedly restricted supply of aneurin, all glandular organs—thyroid, pituitary, suprarenals, ovaries, etc.—are under-developed, their hormones and their physiological activities are short-lived. Well may the question arise as to whether or not those social customs, associated with the reproduction of the species, are determined by the time of optimal development of reproductive hormones, which, in the final analysis, is dependent upon an adequate supply of essential vitamins. Where aneurin is deficient in the diet of the mother, the child may show signs of beri-beri and may die of paralysis, convulsions or heart failure.

In determining the aneurin content of foods, several methods have been used. The first were biological. The rat, having little store of aneurin, fed on a standard aneurin deficient diet was soon depleted of its vitamin, as shown by the cessation of growth. It was then fed that amount of aneurin which would induce growth at the rate of 3 grams per week for a period of 6 to 8 weeks. With the synthetic preparation of aneurin, the method becomes simpler and more accurate. A known amount of aneurin is fed to a group of rats while known amounts of the foodstuff are fed to other groups. That amount of foodstuff, which when fed to the group gives a growth curve parallel to that of the known amount of aneurin, contains the amount experimentally administered.

Interesting as a recent development is the use of microbiological methods, based upon the fact that aneurin is essential for the growth of several organisms.

Most important among all facts concerning the bodily requirements of aneurin is that the amount is strictly related to energy needs. During the war millions of men and women were recruited and examined as to their physiological and psychological fitness. To determine a man or woman's fitness for the performance of industrial or military duties, it is necessary to examine the effect of environment, nutrition and fatigue upon performance. In assessing the amount of aneurin,

or any nutrient, which will permit a predetermined amount of work to be done without any sign of deterioration in its performance, rigidly standardized tests must be employed. These tests are influenced by such factors as pre-test activity, sleep, food, emotional states, temperature and relative humidity. The simplest of the tests applied are the bicycle, stepping, and the treadmill. The treadmill is the easiest to standardize, the bicycle and the stepping tests are more convenient to use and give reliable results.

The international unit of vitamin B_1 has been defined as 3 μg. of aneurin hydrochloride. As a result of many experimental tests, it may be accepted that 0·5 milligram or 166 I.U. of aneurin hydrochloride per 1000 Calories is an adequate amount for an adult. The recommended allowance of the National Research Council, U.S.A., is slightly higher than this. The nursing mother requires most, and it would be safe to say that for her the diet should supply at least 2·0 mg. per day.

Foodstuffs which are rich sources of this vitamin are: wheat germ, rice germ, egg-yolk, yeast, ox liver and the pulses, i.e. beans, lentils, peas, soya bean. With regard to the cereals an interesting differentiation has been established between the constituents of the grain. The largest deposit of this vitamin is in the germ; the bran (i.e. the pericarp and aleurone layer) contains very little. The endosperm has none (see chapter on Bread). The diagram (Fig. 8) will show these important points, and the effect of milling or polishing the grain will be at once evident. The most important part of the cereal as a source of the vitamin is the germ. In the case of wheat and rice, the germ, weight for weight, is many times more potent than the bran in the cure of polyneuritis, indeed, the amount of aneurin in bran may be regarded as negligible. Hovis, a germ bread, is prepared from three parts of white flour and one part of wheat germ, and approximates wholemeal bread in its vitamin B_1 content. White flour contains relatively little vitamin B_1 compared with wholemeal flour. English whole flour, 100 per cent extraction contains 294 micrograms of vitamin B_1 per 100 grams; 85 per cent extraction, 258 micrograms; 70 per cent extraction, 87 micrograms per 100 grams of flour. This means that in milling English wheat to 70 per cent extraction 71 per cent of vitamin B_1 is lost.

The pulses—peas, beans, lentils—are valuable sources of

vitamin B_1, as are meat offals—heart, kidney, liver—and bacon, pork and eggs. Milk should not be regarded as a good source; beef and white bread are lacking in it. While spinach and carrots contain the vitamin, they are not to be commended as good sources of supply. These facts are of importance when we know that so many people in this country live on meat, sugar, bread and highly refined cereals. Professor Cathcart and Dr. Murray of Glasgow, showed many years ago that many working men and women who were consuming over 3000 Calories per day, derived 64 per cent of their energy from these foods which are poor sources of or entirely lack Vitamin B_1.

TABLE 19

VITAMIN B_1 (ANEURIN: THIAMIN) FOODS—EDIBLE PORTION

Micrograms per 100 grams.

Wheat germ	2,000	Milk, whole fresh	45
Flour (English) 100% extraction	294	,, powdered whole	300
,, ,, 85% ,,	258	Egg, whole fresh	150
,, U.K. 1943, 85% ,,	300	,, dried	400
,, ,, 1945, 80% ,,	243	Potatoes (all kinds)	120
,, ,, 70% ,,	87	Peas, green	420
,, Manitoba 100% ,,	363	Pulses (i.e. haricot beans, lentils, peas (split and dried), Soya bean flour)	450
Brown bread 1943	183		
National bread 1943	150		
Heart	600	Brussels sprouts (25%)	120
Liver	400	Kale (30%)	120
Bacon	500	Chocolate, milk	120
Pork	700	Cocoa	120
Roe, cod	1,500	Yeast (edible food)	2,000

Figures in brackets represent percentage wastage.

RIBOFLAVIN (B_2 : G)

In 1927 Sherman and his co-workers had experimentally proved that there was another growth promoting vitamin which did not cure polyneuritis. This vitamin, found in autoclaved or heated yeast, was recognized as the pigment to which the greenish colour of whey is due and accordingly it received the name lactoflavin. It was found to be present in milk in conjunction with carotene the precursor of vitamin A. The complexity of the new vitamin was revealed by the studies of Otto Warburg in Berlin, who had discovered what he called a "yellow oxidative enzyme", or yellow respiration ferment, which plays a part in all cellular respiration. Later it was

shown that this enzyme was found to consist of a combination of protein, phosphoric acid and lactoflavin. When chemists had determined the structure of the vitamin or pigment, they renamed it riboflavin, because of the nature of the sugar which formed a part of it. The alphabetic terminology B_2 and G has been discarded: the name riboflavin was officially decided upon by the Council on Pharmacy and Chemistry of the American Medical Association in 1937.

The principal activities of riboflavin are to promote growth and to maintain a healthy condition of the skin in man and the coat in animals. Dr. Sydenstricker has described the

Table 20

RIBOFLAVIN-FOODS—EDIBLE PORTION

Micrograms per 100 grams.

Liver (raw)	3,000	Eggs (dried)	1,300
Kidney	1,950	Egg-yolk	560
Veal	370	,, -white	220
Lamb	280	Flour, National (85 % extraction)	200
Beans	100	Broccoli (30%)	350
Beef	200	Kale (30%)	500
Wheat germ	700	Cabbage (30%)	100
Milk	150	Cauliflower (30%)	180
,, dried whole	1,600	Spinach	350
Buttermilk	150	Peas, fresh (60%)	225
Cheese (average)	520	Mangoes (40%)	230
,, cream	100	Yeast (brewer's dried)	6,000
Eggs, fresh	350	Pulses (dried)	300

Note.—The figures in brackets represent the percentage wastage in the foodstuff as bought.

clinical condition following riboflavin deficiency, namely a cracking of the skin at the corners of the mouth, glossitis—a smooth condition of the tongue—a dermatitis around the folds of the nostrils, all of which respond promptly to treatment with riboflavin, or foods rich in it (Figs. 18 and 19).

Sydenstricker and his associates have also described the effects of riboflavin deficiency upon the eyes. Photophobia (fear of the light), burning of the eyes, corneal ulcers, corneal vascularity, dimness of vision, etc., are among the symptoms. Again the response to specific treatment is most satisfactory. It may be mentioned that no satisfactory response was obtained when the patients were given vitamin A, aneurin, ascorbic acid or nicotinic acid.

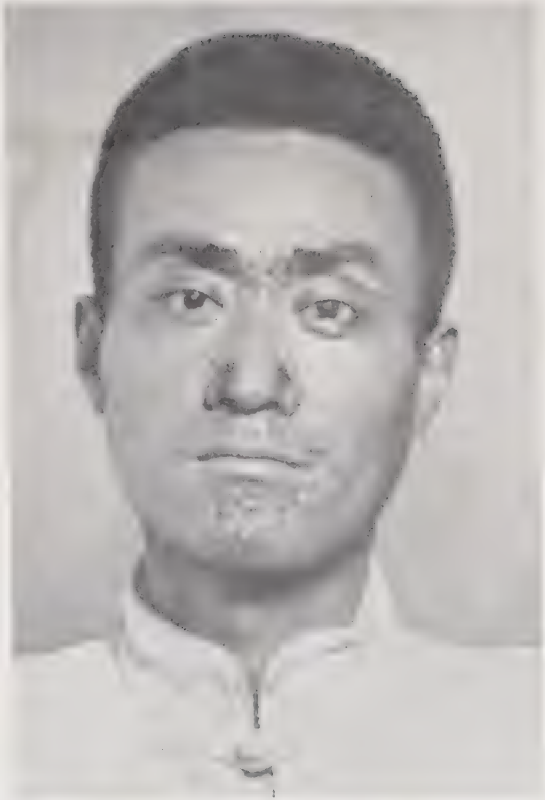

FIG. 18.—A case of ariboflavinosis showing seborrhœic excrescences on the forehead, nose, cheeks, lips and chin and around the naso-labial folds.

FIG. 19.—The same case after treatment with riboflavin 15 mg. first two days, 10 mg. for the next two days and 5 mg. daily for one week.

[*By courtesy of Dr. Bernard Read and Dr. H. C. Hon, Shanghai, and Messrs. Wm. Heinemann, Ltd.*]

[*To face page* 120.

Many of the foods which contain aneurin are fortunately rich in riboflavin: the exception is egg-white which contains no aneurin. The best source is brewer's yeast, followed closely by liver and kidney. Egg-yolk, milk and cheese are also good sources as are also the green leafy vegetables and beans.

The daily requirement of riboflavin is, in milligrams, 50 per cent greater than that for aneurin, i.e. about 2 to 3 mg. per day.

NICOTINIC ACID (Niacin: P.P. Factor)

About the middle of the eighteenth century a disease was described under the name, "mal de la rosa", as being prevalent in Italy, Roumania and other Southern European countries. In the early years of the twentieth century it caused some concern in the United States and under the name "Pellagra" was described as a disease affecting the alimentary tract, the skin and the nervous system. The skin lesions are typical, being confined to the dorsal surfaces of the hands and feet, the forearms and legs, and the face and neck, where the skin finally becomes dry, thickened and of a dark red colour (Figs. 20 and 21). Symptoms associated with the nervous system range from lassitude and irritability to profound depression and ultimately dementia. It is a poor man's disease and in the United States of America is definitely related to the cotton areas of the South. The fact that the diet of those most commonly affected was composed of cornmeal, white flour, sugar, molasses, and polished rice, led Goldberger in 1919 to carry out a nutritional experiment on twelve men who voluntarily subsisted on the diet mentioned and of whom six developed definite signs and symptoms of pellagra. It was subsequently discovered that autoclaved yeast, that is yeast with no aneurin, contained a substance which would prevent pellagra. To this substance was given the name "P.P. factor" (pellagra-preventing factor). Since riboflavin is present in heated yeast, it had to be eliminated as the curative factor in pellagra. It was soon demonstrated that riboflavin had no influence upon the course of the disease. In 1937 Elvehjem found that nicotinic acid or its amide would cure pellagra in two to three days even when the patient showed signs of marked mental derangement.

Clinical studies in pellagra show that nicotinic acid is essential

for the normal activity of the alimentary tract, the skin and the nervous system. It has been suggested that nicotinic acid may play some part in regulating the carbohydrate metabolism of the brain (Himwich, Spies, *et al.*, 1940). This may afford ultimately an explanation of the mental symptoms which are seen in cases of pellagra; these are restlessness, irritability, depression and apprehension, which may lead to marked emotional disturbances and an entire breakdown in personality. One can see in the progression of signs and symptoms which characterize developing pellagra, the whole gamut of changes which lead to the breakdown of individual morale. Perhaps nowhere so much as in the study of vitamin B complex deficiencies, does one become so fully aware of the part played by food in the maintenance of national morale.

TABLE 21

NICOTINIC ACID IN FOODS

Micrograms per 100 grams

Liver (fresh)	10,000	Wheat 75 % extraction	800
Kidney	17,000	,, 70 % ,,	750
Yeast (dry)	10,000	Salmon	8,000
Wheat 100 % extraction	4,800	Herring	3,000
,, 85 % ,,	1,050	Milk	250

Our knowledge of the human requirements of nicotinic acid is incomplete; it is suggested that the daily requirement is about 10 to 15 mg. Dietary surveys in rural and mining areas in U.S.A. have clearly shown that where, as in rural areas, an adequate amount of eggs and milk was consumed, no pellagra was seen, while in mining areas, deficient in these articles of diet, pellagra was often endemic.

The name " Niacin ", accepted by the United States Food and Drug Administration, was coined by Dr. Cowgill of Yale University, from " ni " for nicotine, " ac " for acid and " in " for vitamin. The name was suggested in order that a nutrient should not, by terminology, have association with the nicotine of tobacco. Although related to the nicotine of tobacco, it has not, of course, its toxic properties. The name nicotinic acid is, however, used in scientific circles.

Foods which are rich in the vitamin are; yeast, liver and peanuts. Meat contains small amounts, but eggs, milk and dairy products, if in liberal supply in the diet, are valuable.

FIG. 20.—A case of pellagra in the London Hospital under Dr. S. L. Simpson. Arm on the left before treatment shows pigmentation and thickening of the skin, which is cracked and glossy. After two weeks' treatment with vitamin B complex but without aneurin (vitamin B_1) the skin is practically normal. [*From Dr. S. L. Simpson, the London Hospital, by courtesy of Messrs. Wm. Heinemann, Ltd.*]

[*At page 122 to face Fig. 21.*

FIG. 21. The feet of the same patient: before treatment the skin is highly pigmented and glossy. After treatment the skin has been almost restored to its normal condition. [*From Dr. S. L. Simpson, the London Hospital, by courtesy of Messrs. Wm. Heinemann, Ltd.*]

[*To face Fig. 20.*

High grade extraction of wheat removes much of its nicotinic acid.

Vitamin synthesis.—The vitamins of the B group still afford an ever expanding field for research which holds for many a speculative interest. Aneurin, riboflavin and nicotinic acid are clearly associated with well defined deficiency diseases. There are however other factors which are of scientific interest, but whose functions are too problematical for any detailed consideration here. These new members of the B_2 group are pyridoxine, pantothenic acid, biotin, folic acid and *p*-aminobenzoic acid. With the exception of the first named, all of them are synthesized by the intestinal flora of animals, and if this can be proved to be true for man, it may explain the fact that none of these factors is associated with a dietary deficiency disease. Pantothenic acid and biotin are also known to be responsible for the growth of micro-organisms. In 1941 it was discovered that a protein of egg white called " avidin ", could combine with biotin to form a non-absorbable compound. It has been stated that avidin in the absence of biotin produces symptoms of " egg white injury "—dermatitis, pallor of the skin, etc.—which are those of a biotin deficiency. The other member of this group of present day interest is folic acid, which, either as a liver concentrate or as folic acid *per se* cures the anæmia, and leucopenia (lack of white blood cells) often caused by the administration of sulphonamides. Para-aminobenzoic acid exerts an important biological action in that it counteracts the anti-bacterial effects of the sulphanilamides. Other interesting members of the vitamin B_2 complex are inositol, choline and methionine. Inositol, the basic structure of the phytic acid, occurs in heart muscle, kidney and yeast ; its absence causes a loss of hair in the rat ; choline prevents the development of fatty liver in depancreatized dogs and methionine is one of the essential amino-acids. There is evidence that vitamin B_1 (Najjar and Holt, 1943), riboflavin (Najjar *et al.*, 1944), and nicotinic acid (Ellinger *et al.*, 1944) can be synthesized in the human alimentary tract. The action of milk in preventing pellagra and maize in producing it, may depend on the effect of these foods on the intestinal flora. One of the startling although not recent discoveries in the vitamin field is the fact that rats could grow and thrive without vitamin B_1 in their food. This ability to grow in the absence of exogeneous vitamin B_1 could only be possible

if the vitamin were obtained endogenously, that is by synthesis within the alimentary tract. When Eijkman (1897) first discovered that polyneuritis was produced in fowls by feeding them polished rice, he also noted that if potato starch were added to the diet they failed to develop this disease. Kon and his co-workers have now brought forward evidence to show that in the presence of potato starch intestinal bacteria do manufacture vitamin B_1. This ability to synthesize vitamin B_1 is called " refection ", meaning to refresh or make again. Refection is no recent discovery (Fridericia, 1926); its chemical explanation, in terms of bacteria and vitamins, has been the subject of much work during the past ten years. These discoveries tend to cast doubt on the generally accepted requirements for various vitamins. The study is however in its early stages and " one would do well to guard against going to the other extreme and placing too much reliance on possibilities of symbiotic self sufficiency of man " (Kon, 1945).

In view of the public interest in the synthetic use of individual vitamins, a word of caution may be necessary. It is becoming increasingly clear that, instead of supplying any one vitamin from the B group, in the treatment of any specific B avitaminosis, it is better to provide all the members of the group. Dr. Marion Richards of the Rowett Research Institute has recently suggested that " improvements effected in poor human diets by means of such simple supplements as inorganic calcium, milk and dried yeast, provide a useful pointer for the post-war feeding of starved populations ". Her work emphasizes the need for caution in any attempt to improve diets by the indiscriminate addition of large supplements of single synthetic B vitamins. Insufficient knowledge of the many interrelated reactions of vitamins demands caution in the therapeutic use of synthetic vitamins and emphasizes the value of a mixed diet supplying all accessory food factors in their natural state.

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CHAPTER X

VITAMINS AND DIETARY DEFICIENCY DISEASES
(Continued)

VITAMINS C, D, E and K

VITAMIN C

THIS is the antiscorbutic vitamin. Scurvy has for centuries been regarded as a disease due to dietetic errors, and rightly so. Amongst sea-faring folk, scurvy has been known to occur after deprivation for long periods of fresh foodstuffs, and it was common knowledge that it could be prevented or rapidly cured when fresh vegetables or fruits were available. The disease was long thought to be due to the effects of northern sea climate and the use of salt meat. The ships of the British Naval and Maritime Services were the scene of many an experiment carried out on the unfortunate human material which circumstances so liberally provided. Two instances may be quoted from the Medical Research Council's Report on "Vitamins" (1932), which show how surgeons and others in the Navy were constantly attempting to find out the cause of this disease so dreaded by seamen and explorers. In the year 1747 the surgeon of H.M.S. *Salisbury* wrote: "On the 20th of May, 1747, I took 12 men in the scurvy on board the *Salisbury* at sea. They all had putrid gums, the spots, and lassitude with weakness of their knees. They all lay in a proper apartment for the sick in the forehold and had one diet common to all, viz. water gruel sweetened with sugar in the morning, fresh mutton broth oftentimes for dinner; at other times light puddings; boiled biscuit with sugar, and for supper barley and raisins, rice and currants, sago and wine or the like. Two of these were ordered each a quart of cyder a day. Two others took twenty-five drops of 'elixir vitriol' three times a day, upon an empty stomach; using a gargle strongly acidulated with it for their mouths. Two others took two spoonfulls of vinegar three times a day upon an empty stomach; having their gruels and other foods well acidulated with it, as also the gargle for their mouths. Two of the worst patients, with the

tendons under the ham rigid, a symptom none of the rest had, were put under a course of sea water. Of this they drank half a pint every day, and sometimes more or less as it operated as a gentle physic. Two others each had two oranges and one lemon given them every day. These they ate with greediness, at different times upon an empty stomach. They continued but six days on this course, they having consumed the quantity that could be spared. The two remaining patients took the bigness of a nutmeg three times a day of an electary recommended by an hospital surgeon, made of garlic, mustard seed, balsam of Peru, and gum myrrh; using for common drink, barley water well acidulated with tamarinds; by a decoction of which with the addition of *cremor-tartar* they were gently purged three or four times during the course.

"The consequence was that the most sudden and visible good effects were perceived from the use of the oranges and lemons; one of those who had taken them being at the end of six days fit for duty. The spots were indeed not quite off his body, nor his gums sound; but without any other medicine than a gargarism of 'elixir vitriol', he became quite healthy before we came to Plymouth, which was on the 16th June. The other was the best recovered of any in his condition; and being now deemed pretty well, was appointed nurse to the rest of the sick.

"Next to the oranges I thought the cyder had the best effects. It was indeed not very sound being inclinable to be aigre or pricked. However, those who had taken it were in a fairer way of recovery than the others at the end of the fortnight, which was the length of the time all these courses were continued, except the oranges. The putrefaction of their gums, but especially their lassitude and weakness, were somewhat abated and their appetite increased by it.

"There was no remarkable alteration upon those who took the electary and tamarind decoction, the sea water or the vinegar, on comparing their condition with others who had taken nothing but a little lenitive electary and *cremor-tartar*, in order to keep the belly open; or a gentle pectoral in the evening for relief of their breast" (Lind, 1757).

As a result of these experiments, Lind recommended that lemon juice be given at regular intervals to all sailors on British naval vessels when at sea.

A most notable observation was made by Charles Curtis, surgeon of the frigate *Edinburgh*, in 1807. Writing about the treatment of scurvy, he states : " With regard to sea scurvy reports and accounts have been published as if this had been cured at sea by lime or citron juice, lemon rob, and nitre dissolved in vinegar. But there is a plan for the cure of this disease which depends upon a fresh vegetable diet, greens or roots in sufficient quantity. To be sure we cannot have a kitchen garden at sea and a short and scanty crop of green can only be raised on board ship, but beans and peas and barley and other seeds brought under the malting or vegetating process are converted into a state of a growing plant, with vital principle in full activity throughout the germ and pulp, and if eaten in this state without any sort of preparation, except that of separating or rejecting the husks, cannot fail to supply precisely what is wanted for the cure of scurvy, viz. fresh vegetable chyle."

Here is the heart of the problem, the essential substance is associated with active metabolic processes. The distribution of this factor (vitamin C) thus presents a marked contrast to that of the antiberi-beri vitamin B_1, which is found chiefly in dry seeds.

After many experiments on fruits, cereals and vegetables in which it was discovered that their antiscorbutic properties were destroyed by heating, the essential substance was extracted from orange juice by means of alcohol. The name, vitamin C, was given in 1920 by Sir Jack Drummond. The structural formula of vitamin C was determined in 1933 by Professor Haworth of Birmingham University and he and Professor Szent-Györgyi of Hungary, proposed the name ascorbic acid, by which the vitamin is now known.

Effects of Vitamin C Deficiency.—In scurvy the first symptoms are tenderness and swelling of the joints ; ultimately hæmorrhage of the soft spongy gums, and from the mucous membrane of the stomach and intestine supervenes. Some believe that gastric and duodenal ulcers may be associated with a deficiency of this vitamin. The changes in the structure of the bones and teeth in children can be seen by X-ray examination long before the naked eye-signs are noticeable. Another point of interest is that this vitamin is responsible for the normal condition of the endothelial lining of the blood vessels, particularly the capillaries. As a result of the swelling of the

endothelium, due to a deficiency of vitamin C, the blood fails to pass through these small vessels at the normal rate of flow. There results, therefore, stagnation of the blood and a deficient oxygenation of the tissues from which proceed fatigue, breathlessness, debility and anæmia. In some cases the vessels rupture, giving rise to small extravasations of blood. Research workers in Sweden have noted that at the end of the winter season many people show the effect of a low-grade shortage of vitamin C. One of the tests applied to detect this is to measure the capillary pressure in the skin. At the end of the long Swedish winter, the capillaries (the smallest blood-vessels) in 10 to 25 per cent of the people examined show inability to withstand increased pressure from within. Göthlin has made this interesting observation in describing the effect of vitamin C medication in a 12-year-old country girl: " I shall never forget how this little girl with the dull-tired, resigned expression of face, through five weeks of intensive treatment with orange juice awakened, so to speak, how her movements became livelier and her eyes grew bright, and how her looks showed what pleasure she got out of life." This story can be repeated not only over the whole of Europe, but in the American continent and in India.

Vitamins B and C have a distinct effect in helping to maintain the body's resistance to infection. This is, as has been pointed out, also a characteristic of vitamin A. Many cases of so-called rheumatic pains, which come and go and which are so common in this country, are doubtless due to a lack of vitamin C.

The part played by vitamin C in the development of strong teeth and healthy bones will be described in the chapter on dental caries.

What, then, are the foodstuffs which will supply so important a vitamin? They are chiefly certain vegetables and citrous fruits. Of the leafy vegetables the fresh green leaves of Brussels sprouts, cabbage, kale, parsley and watercress are excellent sources, while of the root vegetables, raw Swede turnips are useful. Potatoes because of the extent to which they appear in most dietaries are a valuable source of vitamin C. Carrots, lettuce, celery and onions are of little value. Peas and beans which have germinated have the vitamin, but if dry they are useless. It has long been known that oranges, lemons and grapes are the finest sources of vitamin C. As we shall see, much that

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is interesting in the history of the vitamin is associated with the use, or the failure to use, these fruits. Tomatoes, raw or cooked, are good, as are also bananas, apples, peaches, pineapples, raspberries and strawberries.

It is surprising to know that the juice of West India limes is distinctly inferior to that of oranges, lemons and of the sweet lime. Orange juice will retain its vitamins at high potency if kept at room temperature and with a small proportion of the oil of the rind in it. Heating to body temperature, 37° C., slowly destroys the vitamin. Oranges and lemons can be kept for months at 2–5° C. without the least detriment to the potency of their juice. Fresh meat is a source of the antiscorbutic vitamin, but it is not by any means a rich one. Milk is too variable to be relied on as a source of vitamin C.

When " lime juice " became the juice par excellence for the treatment of scurvy, the term was used to signify the juice obtained from Mediterranean lemons. The British Navy pinned its faith to " lime juice " until the middle of the 19th century. Owing to political reasons and to favourable reports on the acidity and antiscorbutic properties of the juice of the West India limes the supply of this juice was substituted for that from Mediterranean lemons. From 1804 until about 1860 lemon juice was the official issue. Scurvy had become a comparatively rare disease in the Navy. By 1870 very little, if any, lemon juice was in use in the Navy ; the juice of the West Indian lime had taken its place. This change, while having apparently no great effect in the Navy, had disastrous results in that explorers, following the official lead, resorted to West Indian limes for their supplies of antiscorbutic foodstuffs. The most impressive example of the result of this change is that of the relief expeditions sent out in search of Sir John Franklin, first between the years 1847 and 1859, and then in the year 1875. Those ships which formed the first expedition were supplied with lemon juice, and enjoyed a remarkable immunity from scurvy for long periods of time. The second relief expedition which was sent out in 1875 was not strictly a relief expedition. It had two purposes : first, to find traces of Sir John Franklin ; and second, to make an attempt to reach the North Pole. This Polar Expedition, as it was called, saw two ships, the *Alert* and *Discovery*, equipped with all the improvements that the experience of the previous 20 years had made possible, and with a liberal supply of *lime juice*

of the best quality. The expedition was a failure largely because of scurvy in the crews of these ships, and the Admiralty Court of Enquiry in 1876 could come to no conclusion as to the cause of the tragedy. To-day Arctic and Antarctic expeditions take liberal supplies of concentrated lemon juice, e.g. the British Arctic Air Route Expedition to Greenland (H. G. Watkins, 1930–31).

It should be emphasized that dried vegetables are of no value for the prevention of scurvy since all their antiscorbutic properties have been destroyed in the drying.

Many observers in the past have noted that the anti-scurvy value of fresh meat, though significant, was much inferior to that of vegetables and fresh fruit. Nansen and Johansen, after leaving the *Fram*, spent nine months, including the winter of 1895–96, on Frederick Jackson Island in a rudely constructed hut. They remained in good health and free from scurvy, although obtaining no lemon juice and no fresh vegetables, and subsisting mainly on fresh walrus and bear meat preserved by the arctic cold.

Jackson and Harley (1900) describe an interesting incident at Kharborova, Yugor Straits, where six Russian priests arrived in the autumn, attended by a small Russian boy. The priests by their religious vows were prevented from eating the fresh meat available: they subsisted on salt fish and there were no vegetables. In the following May the little boy was found to be the only surviving member of the party, and had buried all his late masters in the snow. He suffered from no religious disability and had fed largely on reindeer meat through the winter.

A Classical and War-time Experiment on the Distribution of Vitamins B_1 and C.—The deficiency of vitamin B_1 in white wheaten bread is under ordinary conditions made good by the varied diet enjoyed by Europeans. If, however, a mixed diet is derived from canned and preserved foods the case is otherwise, and beri-beri may be expected to appear. This was, no doubt, the cause of the beri-beri which was reported among our troops in the Great War, 1914–18, in the Dardanelles and in Mesopotamia (Wilcox, 1916). In the latter campaign it is illuminating to note that the disease was confined to the British troops and was not reported among the Indian soldiers. This immunity was to be expected, for, in addition to atta, a coarsely ground whole wheat flour, the

native soldier received a generous daily ration of dhal or dry pulses of various kinds, which are rich in antiberi-beri vitamin.

The difference between the types of cereal ration issued respectively to the British and Indian troops was the basis of an unconscious experiment which took place during the siege of Kut-el-Amara (December 1915–April 1916). In his account of the medical arrangements during the siege, Colonel Sir P. Hehir, I.M.S. (1917), wrote: "In an early stage of the siege, a recrudescence of beri-beri among British troops gave rise to some apprehension, but it then disappeared; whilst in Indian troops and followers during the latter half of the siege scurvy caused anxiety". At another place in this diary we learn that "the British troops were receiving white wheaten flour until 5th February 1916, after which date they were compelled to take part of their flour ration in the form either of barley flour or of atta. It is very significant that beri-beri should have occurred while the British troops were enjoying white wheaten bread and that it should have cleared up when they were compelled to share the coarsely milled, germ-containing flour of their Indian comrades." The incidence of scurvy during this siege showed an entirely opposite distribution. The British soldiers were protected by the large ration of meat, 8 to 20 oz., including horse flesh, which they consumed, while the Indian soldiers, largely vegetarian in habit, refusing meat on principle, suffered terribly from this disease.

The lesson to be learned from their experience is that germinating pulses contain vitamin C. Had the Indian dhal been moistened and allowed to germinate in the sun it would have contained the vitamin giving protection against scurvy. This possibility was discovered in 1916 by Dr. Harriette Chick, of the Lister Institute, London. Had these facts been known in 1915, one can well imagine that the fate of the garrison under General Sir Charles Townshend would have been different.

Human Requirements of Vitamin C.—Much controversy has centred around the adult requirement of vitamin C. It has generally been accepted that 50 mg. per day of ascorbic acid are sufficient. During the war, experiments on R.A.F. personnel certainly indicated a much lower requirement, namely 17 to 26 mg. per day. On these amounts thousands of young men have shown no signs of deficiency of this vitamin. Individual investigators have by tests on themselves and others

corroborated the claim for a minimal value of 25 mg. per day. It would, therefore, appear that 50 mg. of vitamin C per day is an optimal figure for a normal adult. A nursing mother should receive 100 mg. per day. Human milk contains approximately 6 mg. per 100 c.c. ; if 600 c.c. of milk were secreted per day, the child would receive 36 mg. vitamin C which is sufficient for a child up to 12 months of age.

Vitamin C is essential for growth and therefore children require more than an adult. The requirements for children are 50, 75 and 90 mg. per day at 5, 12 and 15 years of age respectively. The activity of vitamin C is essentially that of the formation of intercellular substance whereby tissue cells are held together in correct relation to each other, thus permitting them to function properly. In the old days at sea, persistent boils, open wounds, bleeding gums and weak ligaments were common. The part played by vitamin C in wound healing is well described by Crandon who subjected himself to wounds made on his back under normal conditions and also after six months on a vitamin C deficient diet when signs of scurvy had appeared. The results were corroborative of the work of many investigators. Briefly, it was shown that, after six months on a deficient diet, a wound would heal apparently satisfactorily but when examined on the tenth day it was found that beneath the skin there was no healing and the wound was filled with blood clot. The wound had to be opened and drained and the subject was given 1000 mg. of vitamin C by intramuscular injection. Ten days later, examination showed excellent healing. Wounds break down because of the absence of the intercellular substance—collagen—and the injection of vitamin C will prevent wound disruption from this cause. There are, of course, other causes of delayed healing of wounds and there are parts of the body other than skin or muscle where a lack, or the presence, of intercellular substance may be responsible for normal physiological events, e.g. the release of the ovum from the ovary and its implantation in the uterus. A lack of vitamin C in the diet leads to arrest of formation of enamel and cementum of the teeth (Fish and Harris, 1934).

The international unit of vitamin C is 0·05 mg. pure *l*-ascorbic acid.

Loss of vitamin C in foods during storage and preparation is important. For example, potatoes in storage may lose 50

per cent of their original vitamin C content, depending upon the length of time they are stored. If, however, potatoes are left until sprouting begins or is about to begin, the vitamin content increases and the original amount may be almost wholly restored.

The shortage of citrous fruits during the war has aroused a certain amount of interest in the sprouting of legumes. Bean sprouts are well known in China, where much use is made of young growing vegetable foods. In this country if it is wished to increase the vitamin C content of legumes (peas, beans) it would be necessary to soak them in lukewarm water for 24 hours, and, having drained them, to allow them to germinate for 4 or 5 days. In China they are generally kept on a piece of matting in a wooden receptacle with small holes in the bottom to allow the warm water to filter away slowly. Good drainage prevents the lower layer of beans from rotting and also mould formation, which is apt to occur if too much warm water is used. The aim is to produce succulent shoots by a slow process of germination extending over one week.

It is, therefore, necessary in considering the supply of vitamin C to be aware of the changes that take place in storage, preparation, cooking and serving. It must not, however, be assumed that a loss of vitamin C condemns any vegetable; it will still provide its quota of Calories, protein, iron and mineral salts.

In assessing the value of vegetables as sources of vitamin C the percentage content of the edible portion may be misleading. Account must be taken of the kitchen wastage; this is noted in Table 22, column 2. With foods which are exposed to damage in storage and wastage in preparation, it is best, knowing the risks, to take the vitamin content of the food as purchased as an indication of its vitamin value.

VITAMIN D

Vitamin D is a fat soluble substance which has the power of controlling the deposition of calcium and phosphorus in the tissues. It is necessary for the optimum utilization of these elements, both by maintaining normal assimilation and preventing abnormal loss. While the growth of bones and teeth have been most closely associated with this vitamin, it must be remembered that all growth and repair are dependent upon

the good utilization of the minerals for which this vitamin is essential. It must, therefore, not be neglected as something of value in the nutrition of adults. The part played by vitamin D in securing the full development of the body is best illustrated

TABLE 22

VITAMIN C IN FOODS—EDIBLE PORTION

	Mg. per 100 grams	Wastage per cent	As purchased, mg. per 100 grams
Currants, black	200	0	200
,, red	45	0	45
Oranges	55	25	41
Gooseberries	40	0	40
Grapefruit	40	50	20
Strawberries	60	3	58
Pineapple	20	50	10
Tomatoes	25	15	21
Blackcurrant jam	20	0	20
,, puree	65	0	65
Orange juice (M. of Food)	160	0	160
Rosehip syrup	150	0	150
Asparagus	60	80	12
Brussels sprouts	100	25	75
Cabbage	70	30	49
Cauliflower	70	30	49
Horse-radish	130	55	59
Kale (uncooked)	130	30	91
Parsley	150	0	150
Potatoes (early)	30	7	28
,, (late)	10	25	8
Turnip tops	100	25	75
Watercress	60	15	51
Swedes	40	35	26
Lemon juice	50	0	50
Lime juice	45	0	45

by a consideration of the vitamin D deficiency diseases known as rickets and osteomalacia. These are diseases of mineral metabolism wherein the abstruse chemical changes concerned with bone formation do not proceed normally. Rickets is a disease of children (Figs. 22, 23 and 24), osteomalacia is its manifestation in adults, where in adolescents or in women at pregnancy the bones are robbed of their calcium and phosphorus.

The characteristic naked eye manifestations of rickets are to be found in the long bones and the ribs (Fig. 22). Rickets is due to a deficiency of vitamin D which causes disturbances in the utilization of calcium and phosphorus. The bony changes referred to depend on the rate of growth and the stress and strain upon certain bones at different times in the life of the child (Figs. 23 and 24). The child crawling on hands and knees will show enlargement of the epiphyses at the wrists ; when the child begins to walk, the stress and strain are transferred to the legs and unless the signs at the wrists have been duly noted, the femur and tibia will begin to develop characteristic curvatures and thickenings which to naked eye observation will be seen at the ankles. Other signs are enlarged head, flabby muscles and relaxed ligaments. The deformities are the result of a loss of natural rigidity due, in the absence of sufficient calcium and vitamin D, to a failure of correct bone formation. The deformities of 20 years ago are not so frequent to-day : the bow legs, the anterior curvature of the shin bones, the knock knees, the narrow pigeon chests and spinal curvatures are fast disappearing (Fig. 22). But do not let it be forgotten that even when the naked eye manifestations of the disease are absent, X-ray examinations of the long bones in infants may still reveal the presence of rickets (see Figs. 25 and 26). Radiological evidence of rickets in apparently healthy normal children is not uncommon to-day. Rickets is a disease which has no geographical boundaries. Not so is it with osteomalacia to-day. This is a disease most commonly met in India and China. In India the custom of purdah, practised by Mohammedan and high caste Hindu women, prevents their exposure to the rays of the sun ; this, coupled with a diet consisting chiefly of cereals, poor in meat, with very little milk fat, for the quality of milk in India is invariably poor, leads to faulty bone development. The diet lacks calcium, phosphorus and vitamin D. In China the dietary conditions are practically the same ; millet, rice, a limited amount of poor vegetables, almost no meat or eggs, and in inland China, no fish. Could one expect anything but disaster from such a diet. Professor J. Preston Maxwell of the Peking Union Medical College has shown that there is a very close relationship between the increase in the cultivation of the poppy with an increase in the use of opium and the increase of osteomalacia in the province of Shansi. Opium smoking and the

FIG. 22.—Children 6 years of age showing severe rachitic deformities compared with normally grown child (centre) of the same age. [*By courtesy of Dr. Chick. Crown copyright reserved.*]

[*To face page* 136.

FIG. 23.—Rickets in an English infant. Note the deformity and enlargement of the epiphyses at the wrist. [*From Dr. Donald Hunter, by courtesy of Messrs. Wm. Heinemann, Ltd.*]

[*To face Fig. 24.*

FIG. 24.—Rickets in an English infant. Note the bowing of the tibiæ and the enlargement and deformity of the epiphyses at the ankles. [*From Dr. Donald Hunter, by courtesy of Messrs. Wm. Heinemann, Ltd.*]

[*To face Fig.* 23.

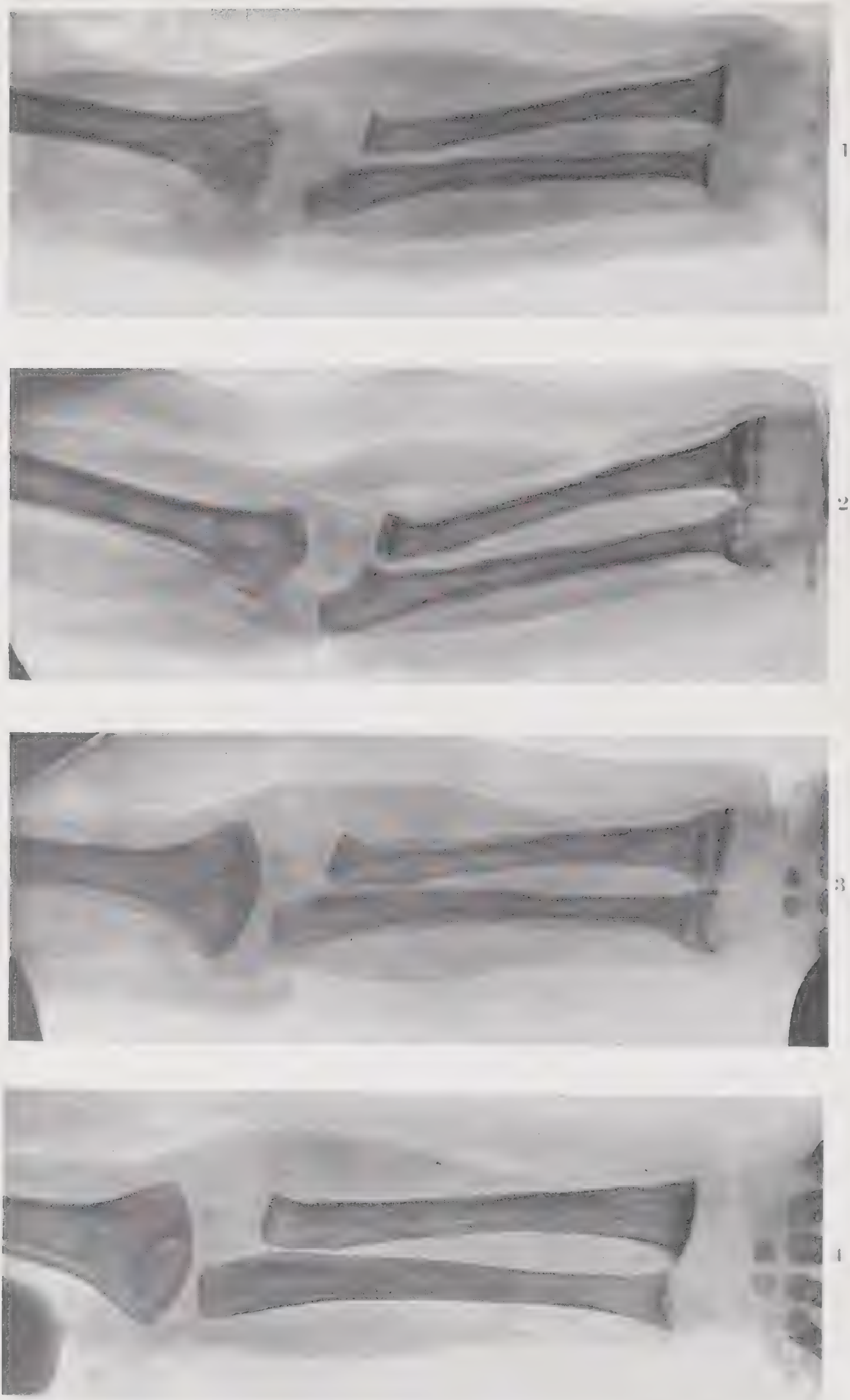
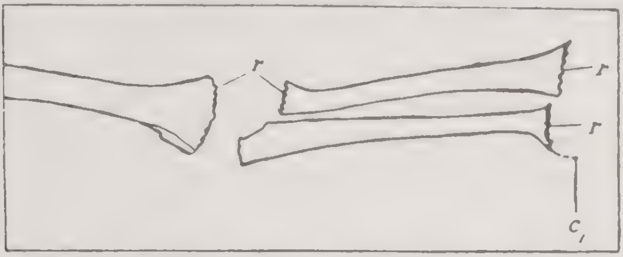


Fig. 25.

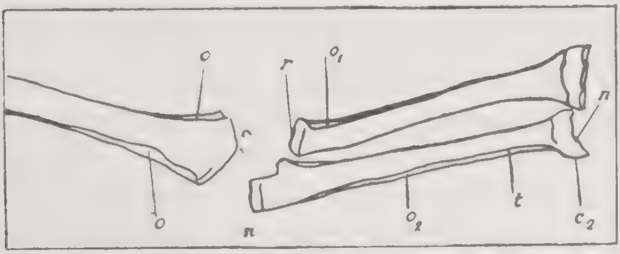
[*By courtesy of Dr. Chick. Crown copyright reserved.*]

[*To face page* 137.

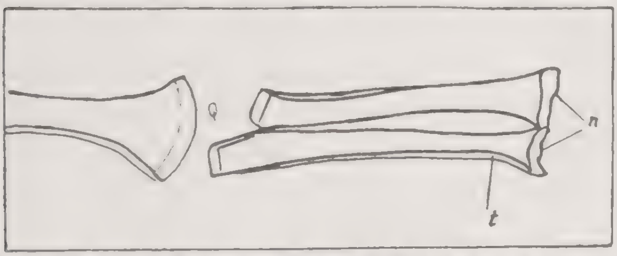
H. K. Case No. 89. Admitted with rickets, treated with cod-liver oil



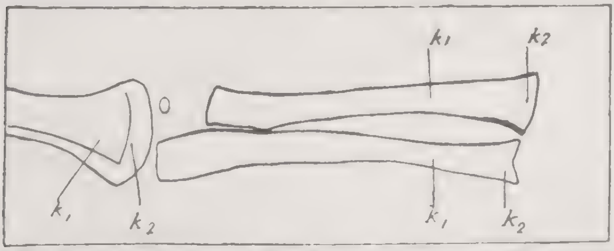
1 (10.3.22.) Florid rickets, no evidence of healing. Osteoporosis present. The structure of the bones is coarse, and the compact bone of the shafts ill-defined and irregular. The metaphyseal margins are frayed (r). The distal end of the ulna is slightly cupped, and there is a faint shadow indicating the expanded, uncalcified zone of osteoid tissue (c_1) which can be detected clinically as an enlargement.



2. (4.4.22.) Healing in progress after 27 days' treatment, showing (1) the deposition of calcium along the shafts of radius (o_1), ulna (o_2), and humerus (o); (2) calcium deposition at the metaphyseal margins and in the osteoid zones previously uncalcified and, therefore, scarcely visible (c_2). These areas are bounded on the side towards the epiphysis by irregular lines of shadow which represent the newly formed zone of preparatory calcification (n).



3. (11.4.22.) Rapid progress in healing. Note (1) the line of dense calcification at the metaphyseal margins corresponding to the new preparatory calcification zone, and (2) the increase in periosteal calcification (osteophyte layer) showing calcified trabeculae (t) running at right angles to the long axis of the layer, (3) calcification of the centre of ossification at the distal end of the humerus.



4. (15.6.22.) Healing well advanced after 3 months' treatment. The contour of the shafts is nearly normal, and the coarse structure has become more finely meshed. A band about 0·5 cm. wide of newly formed bone (k_2) is clearly visible at the distal end of the humerus. At the distal end of the radius and ulna the corresponding band is also to be seen. It can be distinguished by its fine homogeneous structure from the portion of the shaft (k_1) formed before the onset of rickets.

FIG. 26.

binding of the feet of children in China have, because of the enforced seclusion to the house or high-walled courtyard, been definite factors in the ætiology of osteomalacia. In the East osteomalacia is most commonly associated with pregnancy and lactation ; it is also due directly to a deficient intake of calcium, giving rise to what has been called non-tropical sprue. The calcium of the blood is not markedly lowered in uncomplicated rickets, but the reduction in inorganic phosphorus is a valuable indication of the degree to which rickets has developed. A low serum calcium or phosphorus is not necessarily proof of rickets, for other conditions alter the content of these minerals in the blood. There is in the blood plasma an enzyme, plasma phosphatase ; several investigators have found that it is increased in rickets and its estimation is a valuable indication of early rickets, a condition which is difficult to detect clinically or radiologically.

It was proved many years ago that rickets was not due to a deficiency of calcium *per se*. Rickets can be produced in rats by feeding a diet rich in calcium but low in phosphorus and can be readily cured by increasing the phosphorus. The addition of butter fat to such a rickets-producing diet was not altogether satisfactory in curing the disease. On the other hand, cod-liver oil proved most effective. With regard to the part played by cod-liver oil it was found by many workers on both sides of the Atlantic that if oxygen were passed through the heated oil, its growth-promoting vitamin A was destroyed but its antirachitic factor was not. This factor was separated from the fat of the cod-liver oil by Dr. Zucker of Colombia University in 1921 and named vitamin D by Professor McCollum.

It will be remembered that in dealing with the mineral salts of the body reference was made to the deficiency of calcium in the diets of Europeans and Americans. Statistics on this point covering several of the chief towns in Scotland reveal in some cases an alarming lack of calcium. In Dundee, for example, some 10 years ago, it was found that taking the highest standards for calcium requirements, which include that for growth, the necessary intake of calcium was only attained in 9 out of 37 families examined. We do not need to go to India nor China for examples of dietary deficiencies, our own large cities present us with the problems in all their various aspects. Rickets has well been called a disease of " poverty and darkness "

for it is to be found almost exclusively in those children who, living in the slums of great cities, are never well fed and are exposed but little to the direct rays of the sun. In India, where children are allowed to play in the sun, in contrast to the children of the higher castes who are kept with their parents in purdah, rickets is practically unknown. In the Arctic regions where sunshine is limited to a short summer, children are adequately protected from rickets because their mothers, who eat a diet rich in fish oils and fat meat, nurse them over a long period and, after weaning, the children begin early to eat vitamin-containing foods, such as fresh fish and fish livers.

A striking testimony to the value of vitamin C and the fat soluble vitamins A and D is given in Fig. 29. The legend to the figure describes the treatment of the experimental subject and the control, and is a tribute to the work of Drs. Hariette Chick, Hume, Dalyell and others of the Lister Institute, London, which was carried out in Vienna for several years following the Great War of 1914–18.

What is Vitamin D ?—How does the sun produce vitamin D in the body ? It does so in virtue of the fact that certain rays of the sun, rays in the ultra-violet end of the spectrum, act upon a substance in the fat of the skin and thereby produce the vitamin. As one might suppose, there is a great body of evidence behind such a statement. It was very difficult at first to tell just how the sun's rays exerted this apparently magical effect. A clue directing experimental attack in the right direction was supplied rather unexpectedly at the time (1922) by the discovery that the effect of irradiation of the animal could be equally well produced by irradiation of its rickets-producing diet. The experiments consisted of feeding one series of rats on a diet deficient in fat soluble vitamins, of which one is vitamin D, i.e. a purely rickets-producing diet, and another series on a similar diet after it had been exposed to the light of the mercury vapour lamp or to the direct rays of the sun. The rats on the irradiated diet grew excellently and showed no signs of rickets ; the others quickly developed the disease. It was further observed that cod-liver oil could thus be adequately replaced, and it was later found that irradiated liver was of value in preventing rickets. Further research revealed the essential fact, that the capacity to become activated resided in those constituents of the diet which contained fats.

Fats, such as olive oil, cotton-seed oil, vegetable oils inactive in themselves, became markedly antirachitic on irradiation. The part of the fat which is essential contains two closely related substances called ergosterol and cholesterol, which contain fatty acids as an integral part of their structure; only certain rays of the sun will activate these sterols, namely rays with wave-lengths between 280 and 310 millimicrons. The relationship between the mineral salts, the fatty-acid containing substances in foods and in the skin, and the ultraviolet rays of the sun, has been scientifically established.

Ergosterol and cholesterol belong to a group of compounds which have diverse physiological functions; they include bile acids, male and female sex hormones and vitamin D. A pure white crystalline substance isolated as one of the end products of ergosterol irradiation was named calciferol or D_2. This product in large doses will cause loss of weight and deposition of calcium salts in the heart and large arteries. It is strongly antirachitic; 0·025 μg. of calciferol is the League of Nations standard unit for vitamin D activity. Vitamin D_2 is not identical with the vitamin in cod-liver oil which is generally designated D_3. The cheapest source of vitamin D is sunlight, which forms vitamin D_3 from another sterol in the skin, namely 7-dehydrocholesterol. Vitamin D_3 is the natural vitamin D of man. There has been and still is some disagreement concerning the relative values of the synthetic vitamin D_2 (calciferol) and the natural vitamin D_3. The result of feeding groups of ten chicks on these two vitamins is shown in Fig. 30; the chicks receiving the natural vitamin D_3 from cod-liver oil had an average weight of 399 grams; chicks receiving vitamin D_2, 346 grams; chicks receiving no vitamin, 259 grams. The naturally fed group suffered no deaths during the period of feeding; of the others, the D_2 group had a mortality of 50 per cent, and the "no vitamin" group 60 per cent. The advantages of giving vitamin D_3 in its natural form in cod-liver oil, are that it provides vitamin A, a toxic dose of the vitamin cannot be given, because of the large amount of the oil which would be required to approach toxicity and it provides also a high proportion of essential unsaturated fatty acids. It is known from clinical experience that many children, although receiving adequate amounts of vitamin D in their diet, derive benefit from irradiation by U.V. light.

FIG. 29.—A photograph of twins, taken in a Vienna infant's home in 1921, illustrating the striking effect on backward children of medication with antiscorbutics and fat-soluble vitamins. Six months before the date of the photograph the girl, Ida P. (left), at 22 months old, weighed 7·6 kg. (35 per cent below normal); she could neither sit nor stand and made no attempt at spontaneous movement. She had only four teeth, an open fontanelle and other signs of rickets and in her previous history two attacks of scurvy had been diagnosed and treated. During 6 months of treatment, extending from December to June, in addition to the ordinary institution diet which contained an adequate supply of milk, she received daily, 20 g. raw swede turnip juice (occasionally substituted by raw lemon or orange juice), 10 g. butter, later increased to 20 g., and for the last 3 months 10 g. cod-liver oil in addition. At the end of the period she weighed 11·1 kg. (11 per cent below normal), she had 12 teeth, the fontanelle was closed and there was striking remission in all signs of rickets. She could stand and walk a little, she tried to talk and was transformed into a cheery, active little girl.

A control was provided in her twin brother Johann (right) who had also been in the same Institution since birth, and also had suffered from scurvy during the first year of his life, complicated with rickets. While his sister received treatment, however, he had remained in another ward in which no extra vitamin therapy was given. At the time of the photograph, at 28 months of age, his condition exactly reflected that of his sister before treatment. He was feeble, anaemic, showed signs of severe rickets, was unable to sit without support, and gave no signs of intelligence [*after Chick and Dalyell by courtesy of Brit. Med. Jour.*].

[*To face page* 140.

FIG. 30.—Five weeks old chicks. The bird on the left received natural vitamin D_3 from cod-liver oil, the bird in the centre received the same number of International Units of synthetic vitamin D_2 (calciferol), and the bird on the right received no vitamin D. The average weight and mortality of the ten birds in each group were : with the natural vitamin 399 grams and no deaths ; with the synthetic vitamin 346 grams and five deaths ; with no vitamin 259 grams and six deaths. [*By courtesy of British Cod Liver Oil Producers (Hull), Ltd.*]

[*To face page* 141

It may be of interest to know that breads have, in the past, been available to which irradiated ergosterol, in standard quantities, has been added without affecting the taste. Milk has had its low vitamin D content increased by direct exposure to artificial light under suitably controlled conditions, by addition of a standard amount of a fat-free concentrate from cod-liver oil or by feeding irradiated yeast to cows. With regard to the specific rays of the sun necessary for producing vitamin D, it should be emphasized that they do not pass through ordinary window glass. Direct exposure is necessary, but reddening of the skin should be a warning against excessive exposure, which would ultimately lead to destruction of the vitamin. Controlled exposure slowly causing tanning of the skin should be the aim of all sun bathing. The possibility of correct exposure depends on the place, the season and the time of day. In cities, most of the ultra-violet rays are screened out by smoke and dust. In a country with a winter climate such as ours, with its clouds and moisture-laden atmosphere, the only way for children to secure an adequate amount of vitamin D is to take halibut or cod-liver oil or some concentrated preparation of these oils. All concentrated preparations of the vitamin should be taken according to the stated directions for dosage. There is perhaps a slight risk of overdosage, particularly by enthusiastic persons and this is not without its dangers. In our desire to increase weight, to strengthen our bones or those of our children, we may by large doses of vitamin D and calcium salts bring about loss of weight, calcification in arteries, kidneys and muscles. This, of course, is not easily done, but in a day when extremes are not unpopular, a warning is necessary, especially when some of these preparations are many times more powerful than cod-liver oil.

Human requirements of vitamin D are difficult to estimate correctly. The amount of vitamin D formed in the body depends on such factors as climate, season, age and sex. There is a great variability of vitamin D in foods and only a few foods are richly supplied. Experience in children's clinics has shown how much cod-liver oil is required to prevent rickets and to keep a child robust. One teaspoonful of cod-liver oil, containing 450 International Units of vitamin D_3, appears to be sufficient for babies, children and adolescents. In the artificial feeding of infants it should be given in appropriate amounts with each

bottle of milk : this ensures the fullest activity of the vitamin in the retention of the mineral salts—calcium and phosphorus. Growing children, pregnant women and nursing mothers should have at least 1·5 grams of calcium and 2·0 grams of phosphorus per day. While the adult requirement is not accurately known, it is generally maintained that a nursing mother should have about 800 I.U. per day.

Sources of Vitamin D in our Foodstuffs.—The best sources by far are cod- and halibut-liver oils. All fish livers, and particularly those of the fatty fish, are rich in vitamin D. Fresh or tinned herrings, sardines, kippers, pilchards, salmon are of value. Egg-yolk is a very excellent source and therefore

TABLE 23

VITAMIN D IN FOODS

	I.U. per 100 grams
Herring	850
Mackerel	700
Salmon	600
Sardines (canned)	1,000
Egg-yolk	150
Eggs, whole	60
Butter (Empire)	60
Margarine (fortified)	210
Liver	45

VITAMIN D IN FISH LIVER OILS

	I.U. per gram
Tuna fish	10,000
Halibut	2,500
Mackerel	750
Cod (Ministry of Food)	200

eggs are valuable. Cheese is a fairly good source, butter, however, is variable, but because of the quantity of these foods used in the diet, they are regarded as good sources. The vitamin D value of dairy produce and fish varies with the seasons ; in summer, for example, hens' eggs may contain three times as much of the vitamin as they do in winter. Seasonal variations in the vitamin D content of butter are great ; the range is approximately 70 to 350 I.U. per 100 grams (20 to 100 I.U. per oz.). During winter and spring both the flesh and liver of herring have a much lower fat content than during summer and autumn, the maximal range being 4 to 20 per cent of fat. Since the vitamin is associated with fat, it is clear that herring caught in the summer and autumn must have the largest amount of vitamin D. The importance of sunshine for cows, poultry and fish is evident. During the war, margarine was fortified by

the addition of 210 I.U. of vitamin D per 100 grams (60 I.U. per oz.). As a result of the great increase in consumption of margarine due to the drastic fall in imported butter, vitaminized margarine has largely been accepted in the place of butter. Margarine should not, however, be regarded as a perfect substitute for butter. There are no butter fats in margarine, and even if it is fortified with vitamin D_3—not vitamin D_1 nor D_2—it can never be a true substitute for butter. The emphasis must ever be on the natural foodstuff.

VITAMIN E (Tocopherol)

In 1920 it was observed that rats on special milk diets suffered disturbances in the function of reproduction. Two years later the factor responsible for the failure of rats to reproduce was recognized by Evans of California as a vitamin, and in 1936 Evans and several co-workers isolated three different vitamins E, which they named alpha, beta and gamma tocopherol. The name tocopherol, from its Greek derivation (tokos = childbirth ; phero = to bear), indicates precisely the activity of the vitamin. The inability to bear young lay in damage to the placenta, occasioned by a lack of the vitamin in the diet. Other known vitamins and protein as possible factors were excluded. Lettuce dried and heated to destroy vitamin C exerted a curative influence, as did also oil of the wheat germ from which the fat had been removed. When vitamin A is deficient in the diet over long periods, ovulation ceases and generally implantation of the ovum does not take place. Lack of aneurin seriously disturbs the œstrus cycle, while a deficiency of vitamin C leads to disastrous changes in the corpus luteum, the basic structure upon which the development of the placenta and the embedding of the fertilized ovum depends. Vitamin E does not apparently play its part until about one-third of the gestation period has passed and then death of the fœtus may occur indicating a serious deficiency of the tocopherols. Other manifestations of deficiency appear in different species of animals ; nutritional muscular dystrophy may, for example, appear in rabbits, sheep and man.

The vitamin is not formed in the animal body but is synthesized in plant cells, probably in the green part of the plant, and is transferred to the seeds, e.g. wheat germ. Chief sources

of vitamin E are wheat germ and green leafy vegetables of which lettuce is very good. White flour contains none: the loss of germ from the wheat results in the loss of several valuable nutrients.

The international unit is 1 mg. of alpha-tocopherol acetate. The human requirement is about 3 mg. per day.

Much interesting work is being carried out on the relationship between vitamin E and the endocrine organs—thyroid, pituitary, ovaries, testes, etc., as well as on its relation to the function of nerve and muscle. The knowledge of the human requirements of the tocopherols is still very meagre. The best form in which to give the vitamin is whole wheat germ.

Table 24

VITAMIN E IN FOODS

	mg. per 100 grams		mg. per 100 grams
Wheat germ oil	520	Lettuce (dry)	55
Wheat germ	26	Olive oil	8

VITAMIN K (Coagulation Vitamin)

A scorbutic-like condition with subcutaneous hæmorrhages was found in chicks to be due, not to vitamin C but to this new factor, discovered by Dam and Schonheyder in 1936. It was called vitamin K because of its suspected influence upon the regulation of the processes of blood coagulation (Koagulations Vitamin: Danish and German name).

It is now known that this vitamin plays an important rôle in the regulation of the normal function of the liver. A small amount of vitamin K is stored in the liver, but small though the amount be, its presence there is essential for the formation of prothrombin, a substance which, in the presence of ionized calcium salts, is quickly converted into thrombin, an enzyme or ferment which acts just as does rennin in the coagulation of milk, except that it coagulates blood by converting a soluble protein (fibrinogen) into an insoluble one (fibrin).

Now, if the liver be damaged, or there is a lack of bile in the intestine, vitamin K is inadequately absorbed and the prothrombin of the blood is lowered. To reduce the deathrate from hæmorrhage in new-born babies vitamin K is given

to the newly born child or, what is far better, to the mother before the birth of the child.

It must be stated that vitamin K is not of value in the treatment of hæmophilia, that is, a condition where there is a hereditary tendency to bleed profusely from even slight wounds.

Of human requirements the adult amount is not known, but of its importance there is no doubt.

Vitamin K is found in green leafy vegetables, tomatoes, egg-yolk and liver. The green tops of carrots contain vitamin K but the root contains none. Synthesis is markedly influenced by sunlight, and therefore vegetables, e.g. peas, grown in the dark, will contain very small amounts of vitamin K.

TABLE 25

VITAMIN K IN FOODS

	Dam units per 100 grams		Dam units per 100 grams
Purified fish meal	90,000	Alfalfa	20,000
Cabbage leaves	55,000	Tomato (green)	10,000
Spinach leaves	55,000	,, (ripe)	5,000
Cauliflower	40,000	Liver	5,000
		Carrots	1,000
		Potatoes	2,000

NUTRITIONAL LOSSES IN FOOD PREPARATION

The Effect of Cooking on Minerals and Vitamins

The preparation and cooking of foods always results in a variable loss of nutrients, more particularly of vitamins and mineral salts. The loss of nutrients is caused by expression of juices, leaching by the boiling water or condensed steam and hydration. Many vegetables, for example, potatoes, suffer little or no loss of water soluble constituents ; others, such as carrots, swedes and parsnips may lose up to 30 per cent of water soluble substances, while for some, e.g. Brussels sprouts and cabbage, the loss appears to be small. The main cause of loss is the leaching action of the water.

With regard to particular minerals, reference may be made to calcium. In the boiling of vegetables, much of the calcium forms insoluble salts which are not removed by leaching. Interesting is the result of boiling vegetables in hard water as

compared with distilled water; McCance and others have shown that there may be substantial increases in the calcium content of vegetables boiled in hard water, and of iron, where weak acids, liberated during cooking, have dissolved iron or iron salts from the cooking vessels. The addition of sodium bicarbonate increases slightly the loss of water soluble salts, but this is offset by the shortening of the cooking time when hard water is used.

Boiling and frying, so far as potatoes are concerned, results in a loss of water only.

In a paper on this question Dr. C. P. Stewart of the Clinical Laboratory, Edinburgh Royal Infirmary, states: "It is worth while to consider what these losses, which seem so large when expressed as a percentage of the amount present in the raw vegetables, amount to in terms of actual quantities in relation to the daily intake. The following Table shows the mineral losses as compared with the intake from potatoes, carrots and peas in an ordinary meal."

MINERAL LOSSES IN COOKING COMPARED WITH DAILY INTAKE

	Potassium	Calcium	Iron	Phosphorus
	mg.	mg.	mg.	mg.
Potatoes 150 g. . .	144	1·0	0·27	4·5
Carrots 50 g. . .	40	3·4	0·10	2·0
Green peas 50 g. .	76	0·75	0·20	10·5
Total loss . .	260	5·15	0·57	17·0
Daily intake . .	3,400	700	14	1,400

"Though the losses of minerals, as well as of carbohydrate and protein during the cooking of vegetables appear to be of little nurtitional importance, that is merely because the foods are very minor sources of these substances of which the percentage losses are or may be considerable."

The losses suffered by the vitamins may be briefly stated.

Vitamin A.—In domestic cooking there is no appreciable loss; this is due to the fact that vitamin A is not readily soluble in water and is not destroyed by heating, freezing, preserving or canning. Evaporation of milk, as in the process of drying, causes no loss.

Vitamin B_1 Aneurin.—When foods are heated to not more than 120° C. (248° F.) there is little loss. With higher temperatures the loss will depend upon the duration of heating. Pressure cooking, because of the heightened temperatures, is particularly destructive of vitamin B_1. Important, too, is the reaction, that is, the acidity or alkalinity of the water in which the foodstuff is cooked. If it be definitely acid, very little will be lost, provided the temperature is regulated ; if alkaline, the loss will depend upon the degree of alkalinity. Baking soda should not be used in the boiling of vegetables, and water should be kept as minimal as possible. Vitamin B_1, unlike vitamin C, is not destroyed by atmospheric oxygen.

Vitamin C.—If in an alkaline medium, this is the most easily destroyed of all the vitamins, but, under ordinary conditions of cooking, where the cooking medium is not alkaline, the loss is not so great as has been previously suggested. Vegetables and fruits contain an ascorbic acid oxidase, an enzyme which, when vegetables and fruits have been gathered, slowly destroys the vitamin. There are in vegetables protective organic acids which do not allow of such a quick destruction of vitamin C as many have thought. The enzyme is killed at 100° C. : therefore vegetables, etc., should be placed, in small amounts, into boiling water ; in small amounts in order to prevent too great a lowering of the temperature of the water. Certain metals are destructive of vitamin C. They are copper and iron ; therefore copper and iron pots and pans should not be used if vitamin C is to be preserved. Enamel, pyrex glass, stainless steel have no bad effect on vitamin C. The best advice is to place the foodstuff in boiling water, boil rapidly in a conveniently small amount of water, keep the lid on and serve without unnecessary delay. Since 10 to 20 per cent of vitamin C will be extracted, the cooking water should be kept and used. Artificial drying and pickling and pasteurization are deleterious, as are slow methods of cooking. Concerning potatoes, which are a reliable source of vitamin C, the best procedure is to bake them in their skins, the second best is to boil rapidly as has been suggested for vegetables. It has been found that in large-scale cooking, potatoes lose 35 per cent of their vitamin B_1 and 45 per cent of their vitamin C. If left standing on a hot plate, the losses increase to 70 and 75 per cent respectively (Nagel and Harris, 1943). The worst procedure is to mash them,

for by so doing, the surface of the potato is increased a thousand fold and oxidation of the vitamin proceeds rapidly.

A good example of what may happen to vitamin C during the period from its preparation to its being served is what may happen in the potato. A whole potato weighing 100 grams ($3\frac{1}{2}$ oz.) containing, say, 12 mg. of the vitamin, loses 2 mg. in preparation and boiling, and, if served whole and eaten without delay, loses little more. But if it be mashed, thus accelerating oxidation processes which destroy the vitamin, it may contain only 5 mg. on serving, and if kept hot for 30 minutes, this figure may be further reduced to 3 mg. or less when the potato is finally eaten. A similar statement can be made about green leafy vegetables; 100 grams may contain, when bought, 20 to 40 mg. of vitamin C, after preparation and cooking they may contain only 10 to 30 mg., and on serving, 2 to 5 mg.

Vitamin D.—Since vitamin D is not soluble in water and is not affected by heating, freezing or canning, little or no loss occurs in the storage of, preparation and cooking of food.

Vitamin E.—Under ordinary methods of cooking, there is no known loss of vitamin E. Loss of the vitamin is associated with rancidity of fats. This is particularly true of synthetic or concentrated preparations of vitamin E. It may be surprising to some to learn that most foods containing fat are never entirely fresh when prepared for the table; fat has become stale and with it some vitamin E has been destroyed. Pasteurized milk, cheese, butter, etc., may be stale when consumed. If it be desired to secure the optimal absorption of vitamin E in children, it should not be given within three or four hours of the administration of cod-liver oil.

The losses of protein and fat from meat and fish are very variable and it is difficult to assess their nutritive importance. As with vegetables, the losses appear large when expressed as a percentage of the amounts in the raw food, but are insignificant in relation to the total daily intake.

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CHAPTER XI

BREAD

HISTORICAL INTRODUCTION

"For fifteen thousand years the epic of grain has been one with the epic of man." Prehistoric man, by some unknown method of selective breeding, cultivated those grains, the seeds of which could only be removed by trampling, shaking or beating. Four species of grain were known to the ancient Egyptians and to the Chinese as early as 3000 B.C.: they were millet, barley, wheat and oats. Later, rye and rice were cultivated, and only since the discovery of America has Indian corn or maize been known in Europe. The first authentic record which shows how largely grain harvests bulked in the economy of populations is the "Legend of the Seven Years' Famine in Egypt" which describes a period of terrible starvation caused by the failure of the Nile, for seven consecutive years, to reach its usual flood level and thus irrigate the land sufficiently. The legend is also to be seen inscribed on a granite rock on the island of Sehel near Aswan and dates from the Ptolemaic period, although in its earlier form it may be as old as the IIIrd Dynasty, i.e. about 2900 B.C. The event to which the "legend" refers is associated with the famous Imhotep who first appeared "on the stage of history" as the vizier-physician of King Zoser. He it was who, as the Great Magician, advised Pharaoh to make the necessary prayers and supplications in the temple of the god Khnum and to propitiate him with offerings, in order that famine might depart from the land. A similar seven years' famine in Egypt is recorded in Genesis xli. 54, but, on this occasion, in all the land of Egypt there was bread. The whole economy of Egypt depended upon grain, which, in the final analysis, depended on that great gift of the gods, the rising of the Nile. Upon this event the Calendar was based; Egypt's year was divided into three seasons each of one hundred and twenty days. They were named "Flood", "Sprouting of Seed" and "Harvest of Grain", and the beginning of the first season, "Flood", was the first day of the Egyptian year, the day when Sirius reappeared in the morning sky. The grain grown on the rich

black earth left by the receding waters was made into bread by the simple method of allowing the dough to ferment. Spores of yeast plants falling upon traces of sugar contained in the mixture of meal and Nile water, reduced the sugar to alcohol and carbonic acid gas ; the alcohol disappeared, the gas raised the dough, thereby producing bread. The bread was baked in ovens, and in the course of time the bakers made use of sour dough, thus considerably reducing the time required for baking. In these early days of Egypt's greatness, bread was not merely the principal food, it was a mark of culture, a unit of measure and a means of remuneration. From this beginning the baking of bread spread slowly throughout the civilized world. In the slow decline of the Roman Empire, the cultivation of grain steadily diminished : Rome was paying the penalty for neglect of the fertility of the soil, and thus for hundreds of years she had to import grain from Egypt, Spain and North Africa. To Rome, Egypt was for many years a necessity since the gift of the Nile was bread. In the last century B.C. tens of thousands of people received free grain in the great capital of the Empire. In 30 B.C. the Emperor Augustus took possession of Egypt, and at home there was not bread enough for all. In A.D. 69 the revolutionary Vespasian seized the grain fleet ere it sailed from Egypt, had Rome at his mercy and, forcing recognition of his power, became Emperor. As long as Egypt was a Roman granary and in the hands of the Emperor, the proletariate and the army, particularly the latter, could be fed. But a dwindling Empire which, as a last resource, had to feed its legions in northern Europe on corn from England, was a doomed Empire (*ca.* A.D. 300). It was an Empire greatly organized, characterized by the great wealth of a few and the abject misery of many.

When the wild nomadic tribes from the north overran the Roman Empire, two important factors determined the course of man's development ; they were, first, the necessity for nomadic tribes, if they were to live at all, to change the pattern of their lives and to abandon cattle raising in favour of agriculture ; second, the impact of Christianity, which, under Constantine the Great, had been the State religion of the Roman Empire. As the centuries passed, the slave became the serf, and as they continued to multiply and till the soil in the interests of those who ruled over them, there emerged three classes ; the landowners, the serfs and the priests who, serving both, taught

men the simple methods of agriculture. Here began the struggle between paganism and Christianity, between the believers in Odin, the wind god, and those who were anxious that, through religious influence, man should be taught to rule and use, to his advantage the forces of nature. Through the long, dark mediæval age, agriculture and learning were stayed one upon the other. With each recrudescence of paganism, and there were many, the land was laid waste and man suffered not only because of a lack of bread, but because of bread poisoned by carelessness and ignorance in the cultivation of the soil. In A.D. 943 thousands died as a result of eating bread made with rye contaminated by the ergot fungus. It was not until the end of the sixteenth century that the cause of this disease, known as Saint Anthony's Fire, was discovered. Throughout the Middle Ages the development of milling and baking was hindered by superstition and prejudice. Fear of the mill, hatred of the miller and suspicion of the baker, each played its part in stifling the spirit of progress. Hunger had always existed, and recurring famines could only be accounted for on religious or supernatural grounds.

Bread, the fruitful basis of ecclesiastical controversy, the lack of bread, the cause of peasants' revolts and bitter national strife throughout England and the continent of Europe, bread became the watchword of those who demanded "the abolition of serfdom, the right to grind, bake and brew" (Wat Tyler, 1381).

England of the Roman occupation was to a very limited extent in its southern and south-eastern areas a wheat granary for the legions in Britain and on the Rhine. Before the Roman conquest, the chief crop grown was probably oats. Rye, a later addition, making its first appearance in Southern Russia, crossed the European plain, and finally crossing the North Sea to England in the Middle Ages, formed an important part of the food of the people. In some areas of the country more, in others, less rye than wheat was used in the mixture of these two cereals from which bread was made. In certain parts of England where the soil was well cared for, an early transition from rye to wheat began to take place. The reason for this is found in the thirteenth-century Book of the Office of the Seneschal where it reads: "It is the duty of the Seneschal of Lands to protect his Lord's interests, to instruct the bailiffs of the several manors . . . to know how many acres there are

in each field . . . to know how much wheat, rye, barley, oats, peas, beans one ought by right to sow in each acre ". "He must cause the land to be marled, folden upon, dunged, improved and amended . . . for the advantage and betterment of the Manor." Great importance apparently was attached to the process of marling the land, by which fields were fertilized by spreading upon them marl, an earthy substance containing lime, clay and sand in various proportions. The well marled land produced good and assured crops of wheat: to sow two crops together in the hope that at least one would be successful was no longer necessary.

In Tudor times wheat and rye were closely associated; either grown together or the grain from separate fields mixed at the reaping. This mixture of wheat and rye, generally in equal proportions, was called "maslin" and from thoroughly sifted samples of it was made the cream coloured bread of the sixteenth and seventeenth centuries called "manchet". Sometimes wheat was mixed with both rye and barley to make bread, and bread made from such "mixt corn" with "white meats", i.e. milk, cheese and eggs, formed the chief source of sustenance of the yeoman and agricultural labourer up to about the end of the seventeenth century. From now, through the eighteenth century there was a steady decline in the use of rye. In the *Annals of Agriculture* of the year 1796 the following statement again indicates the transition: "in Nottinghamshire oppulent farmers consume one-third wheat, one-third rye and one-third barley; but their labourers do not relish it and have lost their rye teeth". The increase in the use of white flour for baking bread and the ultimate disappearance of rye from English bread was associated with the growth of continental trade, the development of the wool industry and a steady deterioration in agriculture.

At the opening of the eighteenth century it could be said that the shearing of sheep became much more profitable then the growing of corn. The agricultural labourers were fast becoming "the slaves of the loom"; the land was deserted for the misery of slum life in crowded industrial towns. Goldsmith's dissertation on the evils of the transformation due to "Enclosures" is one of the treasures of English verse:

> "Ill fares the land, to hastening ills a prey
> Where wealth accumulates, and men decay".

The cause of the " despair and fell disease and ghastly poverty " was known; the cure, through the planned application of scientific knowledge, was as yet far distant. It is probably quite true that the system of ruthless land enclosures had put agriculture on a progressive basis, and that, at the expense of the economic life of the English countryside. But the swift application of mechanical inventions in industry, the increase in population and the continued drift of the agrarian population to greater employment in the towns and cities called for a larger supply of bread. Industrial revolution had thrown agriculture into dire straits; it had created a situation in England which had within it the seeds of social revolution as dangerous as any in the tragic history of France.

During the eighteenth century there was a comlpete transition from the wheat and rye bread to purely wheat bread. " How was it that rye did not continue to be the main national bread corn in England as long as in Germany? " " The nature of the English loaf was closely associated with the nature of the English agrarian system which was not completed till the seventeenth and eighteenth centuries " (Sir Wm. Ashley). Marling and liming were revived and the soil was so improved that wheat became the more prevalent crop. It may be true that in the sixteenth and seventeenth centuries the cream coloured bread was the emblem of superiority. It may not be true, as frequently stated, that in the nineteenth century the desire of the working masses of England for white bread was an expression of envy and that " to eat brown bread was once a sign of lower class ". May it not be more probable that the " working classes " of the nineteenth century craved white bread for just those reasons which made white bread attractive to all who could afford it? It should be remembered that the white flour of the ancients, the maslin of the Tudors and the highly refined white flour of to-day are not one and the same article. A mortar and pestle, stone grinding, roller milling with varying methods of bolting do not produce a flour of the same content or of a similar degree of whiteness. White flour was known to the ancient Greeks and was valued for the lightness of the bread made from it. Its production necessitated much manual labour, and its fine appearance was due to thorough grinding, efficient winnowing of the chaff and careful sifting. The stone ground corn of England was a valuable foodstuff,

but stone grinding did not produce the fine, light article known to the Greeks and Italians probably as early as 200 B.C.

Modern milling is the result of a long evolutionary period of trial and error whereby the miller has perfected his skill. When roller milling was first introduced in 1830 in Switzerland by the engineer Sulzberger, the millers of Hungary quickly seized upon the idea and in a few years the white wheat flour of Hungary was flooding the world markets. But at the World's Fair in Vienna in 1873 American and English millers investigated for themselves the new technique, with the result that by 1880 roller mills had, in the U.S.A., virtually swept all previous forms of milling out of existence. To American wheat kings, who upon the repeal of the English Corn Laws (1846) had captured the English market and later most of the continental ones, this was another boon. The North American continent had by 1900 become the world's greatest wheat granary. Following an exhibition, in London, in 1881 of the new roller milling technique, British millers, finally realizing that the old method of stone grinding was doomed, gave up all opposition to the new method and the British public got what they wanted, namely, white bread. The popularity of white bread lay not only in its more æsthetic colour, but in certain properties which it possessed. In the days when the housewife baked her own bread it was soon discovered that white flour had better rising properties. The improvement in baking due to finely ground flour was long known; indeed, it was the main reason for adding wheat or maslin to rye in the making of bread. Further reasons for the popularity of white flour at that time were the greater certainty on the part of the housewife in the final result of her baking, a finer cutting quality due to the finer texture of the bread and, to some, a much more attractive flavour. All these properties had no reference to nutritive values, for such were but dimly known. To-day, with scientific knowledge of the nutrients of bread and the possibility of improvement in baking techniques, there should be no reason why the modern flour should be less fine than the best maslin or less nutritious than the coarsely extracted wheat berry of the Tudor period.

THE NUTRITIVE VALUE OF BREAD

The importance of the nutritive value of bread in any diet depends upon the nature of the diet. Where the dietary consists of a fair proportion of animal protein foods and vegetables, the role of bread in it is of far less importance than it is in a diet deficient in these protein, mineral and vitamin bearing foods. In certain parts of the world where cereals form the staple diet, the protein supplied by the cereal eaten is of importance. In the poorer families of the industrialized countries of Europe, bread is a highly important food factor ; for example, in England in 1936 the amount of protein provided by bread and flour was 20 grams per day, which was 33 per cent of the total protein eaten by the poorest 10 per cent of the population. On the continent of Europe, in poor economic groups, the amount of protein from bread may be as high as 43 per cent of the total protein intake. The nutritional value of bread is further determined by the degree of extraction of the grain from which the bread is made, since the more highly refined the flour is, the less nutritious it becomes. Repeated extraction will produce a flour practically devoid of protein, mineral salts and vitamins, leaving only a carbohydrate foodstuff, excellent as a source of energy but valueless in any other respect. High carbohydrate diets require proportionately higher amounts of vitamin B_1. In the whole grains there is a sufficiency of vitamin B_1 to cover the demand made by the carbohydrate they contain. In bread made from highly refined flours there is little vitamin B_1.

In Western European countries the importance, as well as the amount of bread in the diet has decreased during the last fifty or sixty years, because there has been a marked increase in the consumption of meat, eggs, milk, butter, fruit and sugar. It is a well-known fact that the higher the standard of living, the greater will be the proportion of the total energy obtained from animal protein foods. One returns always to the obvious statement that, given a first-class diet, bread can be left to take care of itself. To some such a statement may close the subject, but to those interested in the health of nations, it does not, at least not as long as there are poor economic groups in our midst and under-nourished populations in the world. Bread is the cheapest of foodstuffs. There is no reason why it should

be made the poorest by removing from the wheat berry the valuable minerals and vitamins which it contains. It can be made, and has during the war almost been made, one of the best as well as the cheapest of foods. The consumption of bread in Great Britain compared with continental countries is not very high. In 1909–14 the consumption of wheat was 5·54 bushels, in 1930–31 4·86, and in 1936–37 4·69 bushels per head per annum. (Wheat Advisory Committee's Report, 1938). Until 1939 the bread was practically all wheat bread made from flour of 70 to 72 per cent extraction. Four classes of flour were milled (McDougall) :

1. Bread flour from a mixture of strong and medium strength foreign wheats.
2. Pastry and cake flour from soft home or foreign wheat.
3. Biscuit flour almost wholly from British wheats.
4. Household flour either plain or self-raising from soft wheats.

The different grades of extraction were : (*a*) straight run grades to about 71 per cent ; (*b*) short and long patents of 60 per cent and less ; (*c*) a small amount was milled for brown and wholemeal bread.

" Bleaching was permitted by law. While forbidden in many countries, bleaching has an advantage where the public insists on very white bread. It allows a greater extraction (71 per cent) which retains some vitamin B_1, while without it the extraction would have to be almost 64 per cent to secure the required whiteness in the bread. The bleaching processes (nitrogen peroxide trichloride, Beta gas or benzoyl peroxide) have been shown not to destroy the vitamin B content of flour " (McDougall).

Stone Milling v. Roller Milling

To understand the differences in the nutritive value of flours produced by these two methods, the structure of the wheat berry and the distribution of the nutrients in it must be known : they are shown in Fig. 31. The facts here presented are from a paper by Sir Jack Drummond and Dr. T. Moran and were determined at the Cereals Research Station, St. Albans, by workers whose object was to produce a flour of the highest nutritive value, having a pale colour and good

baking quality (*Lancet*, June 1945). The findings are important. They show that 60 per cent of vitamin B_1 is in the scutellum fraction of the germ, nicotinic acid and iron are concentrated, not in the bran but in the outer endosperm, and the germ as a whole contains appreciable quantities of riboflavin, nicotinic acid and iron. In assessing the possible contribution of the different factors that can be made by endosperm and germ, it must be remembered that the amount of endosperm in wheat is 35 times that of the germ. The mineral salts and the Calories furnished by flours of different extractions have been determined by Professor McCance and his fellow-workers at Cambridge. It has also been found that proteins of high nutritive value are present in the outer layers of the endosperm. Bran includes the aleurone layer which, in milling, is not detached to any appreciable extent. In stone milling both the germ and the bran were ground so finely that they could not be removed by bolting, hence the cream colour of maslin. The word bolting is derived from a corruption of the old French word " bure ", the name given to the coarse woollen cloth used for sifting the flour.

In modern roller milling the wheat germ is not ground but flattened and the bran is flaked, and therefore both are easily separated from the flour in the process of bolting. The percentage of the nutrients in stone ground and roller milled flour is shown in the following Table.

TABLE 26

Nutrients	Stone ground Flour	Roller milled bleached Flour	Percentage loss in Milling
Protein, g.	12·5	10·11	19
Fat, g.	1·4	0·9	36
Minerals, g.	1·1	0·4	63
Calcium, mg.	44·0	20·0	54
Phosphorus, mg.	180·0	92·0	50
Iron, mg.	3·3	1·0	70
Carotene, mg.	0·2	0·0	100
Riboflavin, mg.	0·2	0·01	50
Aneurin, I.U.	100	15	85

The data in Table 26 form the basis of all discussions on bread to-day. Note should be made of all deficiencies of 50 per cent and over.

THE BREAD CONTROVERSY

The bread controversy during the World War, 1939–45, was based on the question, " From what type of flour shall our bread be made ? Shall it be white flour, white flour enriched, or 85 per cent extraction flour ? "

To those who can secure in their diets an adequate supply of milk, eggs, cheese, meat, fish, fruit and vegetables, the white bread made from finely milled, bleached flour is merely a matter of taste and quality. But to those who cannot obtain these foods, protective foods they are wont to be called, such bread is of the nature of a disaster in the nutritional field. It has been shown that bread has been throughout the ages the basal factor in maintaining a stable economy. When one recalls how the lack of wholemeal bread, the nutritious article made from stone ground flour, caused revolt and war in a non-industrial age, one can well imagine what might have happened if industrial advance, which produced roller mills, had not also made possible a wider and better distribution of animal foods. The social and economic history of the nineteenth century reveals the appalling results in human lives wherever roller milled flour was not associated with a sufficiency of the animal foods. It is a curious fact that the problems of peace, which would jeopardize the life of a nation at war, are energetically faced and often solved when the dire emergency arises. In view of the great lack of " protective foods " during the war, a lack which may well continue for some time after the war, the Government undertook the responsibility of feeding the nation. By securing for the people through rationing a fair distribution, at a controlled price, of essential foods and by concerning themselves with the nutritive quality of the people's bread, the Government in war *virtually* solved a peace-time problem. That the problems of food distribution and the technique of baking a highly nutritious loaf from fine flour containing all the nutrients of the wholemeal, have been entirely and satisfactorily solved, bears no admission. That they can be solved none should deny. Of course, " under normal circumstances in a free country, the citizen has a right to choose a deficient diet if he wishes, and to deal with the consequences in his own way " (Samuel Lepkovsky). But rights bear with them responsibilities, and therefore the freer we are the greater the

need for education in order that we, choosing aright, may avoid unpleasant consequences. During the first world war the nutritional value and palatability of "war" bread was investigated by Sir Frederick Hopkins (Cambridge), Professor Noel Paton (Glasgow) and Dr. J. A. Gardner (London) on behalf of the Food (War) Committee of the Royal Society. The war bread was not generally accepted by the people, the chief reasons being the unpalatability of badly baked bread. With better knowledge, better bread could have been made and the nutritive superiority of an 85 to 90 per cent extraction flour would have been more generally recognized From this experience one outstanding fact emerges, namely, that scientific knowledge must be more closely related to technical development. Since 1920 research has shown the value of cereals as a source of protein, the important rôle of the proteins of milk, meat, fish and even fruit in supplementing the proteins of the whole grain, the interplay of vitamins, mineral salts and carbohydrates in the biochemistry of living processes, and the effect of rancidity and staleness on various nutrients such as fat soluble vitamins. In a word, the experiment with bread in the latter part of the first world war, based on scientific advice, was receiving further scientific support. It was no matter for surprise that the whole question of a more wholesome bread should be revived. It may, in view of the knowledge at our disposal, be a matter of surprise that the subject should attain the status of an acute political question. Controversy, not without acrimony, coloured much of the pros and cons of the arguments setting forth views on the question of white versus wholemeal bread, and ignorance, prejudice and self-interest lacked nothing in representation.

On 18th July 1940 Mr. Boothby, Parliamentary Secretary to the Ministry of Food, announced in the House of Commons that, on the advice of the Scientific Food Committee, it had been decided to fortify white flour with vitamin B_1 and calcium. The proposition was supported by Sir Jack Drummond and Dr. Moran, who maintained that "the introduction of the new white flour will undoubtedly stultify the controversy of white versus brown bread". The leading article in the *Lancet* of 27th July 1940 stated: "Modern scientific investigation of nutrition has made it full clear that wholemeal bread is a more nourishing food than white bread and that it would be better

for the nation's health to eat brown bread ". Suggesting that this is sufficient reason for changing from white to brown bread, the " Leader " goes on to say that the question is more complicated than this for " People do not like brown bread, pigs and poultry do like and need the bran and germ which form the milling offals when white flour is milled ; brown flour does not keep ; brown bread needs much more yeast to bake it than white ; brown bread has usually been dearer than white ". It is true that people do not like brown bread unless it is well made : it is also true that pigs like and need the germ, but so do children and other human beings. But enriched or fortified bread became the order of the day. True, the white bread eaters were not yet deprived of their staple luxury, but who could regard white flour fortified with vitamin B_1 and calcium carbonate as in any way equivalent to whole wheat flour ? That there were doubts in the scientific mind concerning the replacement of whole wheat flour by a fortified substitute was evident when the Accessory Food Factors Committee of the Lister Institute and Medical Research Council (London) issued a memorandum on Bread in July 1940, in which they recommended that :

" I. Flour for the bread of the people should contain the germ of the wheat grain, as much as possible of the aleurone layer, and the finer portions of the bran. Instead of flour consisting of about 70 per cent of the wheat grain, as it does at present (1940), the percentage extraction should be at least 80 to 85 per cent.

" II. Bleaching or improving of flour by oxidizing agents or any process which damages the nutritive value of the flour should be prohibited.

" III. The public would be benefited by the addition of calcium salts to the flour from which bread is made. Bread made from flour thus supplemented should be specially designated. The production and consumption of milk, cheese, and vegetables should at the same time be promoted to the maximum extent, in order to secure an adequate supply of calcium.

" IV. The use of baking powders, which produce alkaline conditions, should be strongly discouraged in making bread and biscuits."

The report emphasized the following points with regard to vitamins : (*a*) that the normal sedentary adult required

300 I.U. of vitamin B_1 (aneurin) and that a 1 lb. loaf made of flour of 70 per cent extraction would give 80 to 160 I.U. vitamin B_1, while that made from 80 to 85 per cent extraction flour would give 300 to 450 I.U. vitamin B_1; (*b*) that the change to 80 or 85 per cent extraction flour would benefit adults and children of all classes; (*c*) that the amount of vitamin B_2 (riboflavin) would also be greater in the brown flour; (*d*) that 80 to 85 per cent extraction flour would, by *including the germ*, substantially increase the quantity of vitamin E.

With regard to minerals, it was stated that the human daily requirement of iron may be taken as 10 mg., that a 1 lb. loaf made of 70 per cent flour would supply 5 mg., that, from 80 to 85 per cent extraction flour would supply 10 mg. Calcium as a dietary constituent must be considered in relation to the amount of phytic acid in the particular cereal. In this respect 85 per cent extraction flour contains more phytic acid than the 70 per cent extraction and therefore is not regarded as a good source of calcium, since in the presence of large quantities of phytic acid the metabolism of calcium and phosphorus is impaired. For this reason the Committee suggested the addition of calcium carbonate, and also emphasized the importance of milk, cheese and vegetables. Another possible disadvantage of bread made from a high extraction flour is the reduction in utilization of the nutrients. The report stated, and it is an important fact, that reduced utilization is due to the coarseness of the branny particles and suggested that, if a 90 or even 100 per cent extraction flour could be obtained in a finely ground and homogeneous condition, its nutritive advantages would be still further enhanced and the disadvantages of incomplete utilization would tend to disappear.

The response of Authority to this recommendation is interesting, for the Government decided to fortify white flour with vitamin B_1 and calcium carbonate (7 oz. to the 280 lb. sack of white flour and 14 oz. to the 280 lb. of 85 per cent extracted flour). One year afterwards (May 1941) the bakers had still not received flour from the millers containing either vitamin B_1 or calcium, but *mirabile dictu* the Government had adopted the first recommendation of the Medical Research Council, for Lord Woolton announced in the House of Lords that in view of the unanimity of scientific opinion, the Government had decided to make national wheatmeal bread available to

the public at the price of white bread. The national loaf, baked from 85 per cent extraction flour, but with no addition of calcium, had arrived.

When white flour is milled to, say, 75 per cent, 25 parts go to feed animal stock; with 85 per cent extraction, 15 parts go to the farms and the human consumer secures 10 more parts out of the 25 usually discarded. The important point was to select the best 10 out of the 25 parts usually discarded as offal, and in the selection several factors were considered, namely, nutritive excellence, palatability, æsthetic appearance, digestibility, roughage or fibre content. Following upon such considerations the Medical Research Council issued a second memorandum defining the character of the wheatmeal recommended (31st May 1941). Table 27 gives the two suggested flours: No. 1 was selected because it contained the highest vitamin B_1 content, closely approaching the wholemeal flour value, the fibre content was comparatively low and its appearance was pale brown and the bread made from it most closely resembled white bread in flavour, texture and colour.

The analyses of the flours are shown in the Table.

TABLE 27

Flour, per cent extraction	Fibre, per cent	Ash, per cent	Protein, per cent	Vit. B_1, I.U. per g.	Calcium, mg. 100 g.	Phosphorus, mg./100 g.	
						Total	As phytic acid
I. 85 . .	0·6	0·9	11·4	1·20	27	203	123
II. 85 . .	0·85	0·94	11·5	1·15	27	211	128
White 73 .	0–0·2	0·46	10·6	0·35	15	101	35
Wholemeal 100	1·8	1·51	11·9	1·40	36	343	246

Of the national loaf made from No. I, 85 per cent extraction flour, the leading article in the *Lancet* for 31st May 1941 said: "Few people grasped that the national loaf is probably the best bread, judged on its food value, that they have ever eaten, for it has been selected after a most careful scrutiny of the nutritive value of the different parts of the wheat grain". The protagonists of enriched flour would not accept this, saying that the 85 per cent extraction would sharply reduce milk supplies as a result of the loss of wheat offal for cattle feeding; there would be a net loss of nutrients and the bread would not be

acceptable to the public. The controversy still waged and more rats were fed on diets containing fortified white flour and whole wheat flour. However valuable as an experimental subject a rat may be, and it is most valuable, a rat is not a human being. While the findings on rats can never be entirely accepted as applicable to man they have certainly indicated fruitful lines of study of problems as they may affect man. It is known that breads made from higher extraction flour have a depressing effect on the assimilation of calcium. The depression is of the order of 10 per cent (Henry and Kon, 1945). Despite this slight depressing effect the superior growth of animals receiving wholemeal bread is admitted by many investigators (Chick, 1942; Copping, 1943; Henry and Kon, 1945). It is also true that there is a lower incidence of rickets where whole grain bread is consumed. In baking whole grain bread the phytic acid is in a great measure destroyed by the phytase present in the flour (Mellanby, 1944). It is probably correct that where wholemeal bread supplies 40 to 50 per cent of the daily calories—i.e. about 1 lb. of bread per day = 1200 Calories—the absorption of calcium is depressed (McCance and Widdowson, 1942). The whole question of the metabolism of phytic acid and its effect on the assimilation of calcium must be studied with respect to all the factors associated with the nutritive properties of the wheat berry.

Other pertinent questions arise, one being, "Why was the national wheatmeal loaf so unacceptable?" There are many answers to this question. In a war-time Social Survey made between February 1942 and October 1943 by Miss G. Wagner, it was found that 52 per cent of 2530 housewives questioned, approved of the national wheatmeal loaf, 35 per cent criticized and disapproved entirely, while 13 per cent had no opinion upon the matter. Probably the main cause behind all criticism was a lack of uniformity in the national wheatmeal flour, due to the permission given to millers to mix, up to 15 per cent bran with white flour and still meet the requirements of the Ministry of Food. To add bran to white flour in order to make it equal 85 per cent extraction flour is not the way to make the best selection of the essential nutrients in the wheat berry. The criteria for milling was that the flour should contain 1 I.U. of vitamin B_1 per gram and less than 0·9 per cent fibre. The bran is responsible for the dark

colour, coarse texture and, to some, the unpalatability of the national loaf. The loaf steadily lost favour. " In this conflict between the national and individual interests, the millers have thus won the day and a golden opportunity of furthering the health of the people has been lost " (the *Lancet's* leading article, 15th November 1941).

On the 11th March 1942, the controversy was temporarily suspended when Lord Woolton announced in the House of Lords : " H.M. Government have decided to increase to 85 per cent the ratio of flour from milled wheat in this country. This means we shall stop the production of white bread." Lord Horder, adviser on medical matters to the Ministry of Food, welcomed the decision, saying that he and his colleagues " are uniformly of the opinion that no single step which the Government could have taken in respect of the nation's food is so calculated as this one to raise the level of the nation's nutrition ". " The national wheatmeal bread would be suitable in all forms of illness in which bread is allowed and it would be of greater benefit to those who are still living below the poverty line, for they are the slowest to change old habits in the matter of basic foods." " The victory of science, approved by the highest medical authority, was undoubtedly gained since it had an economic ally in shipping." In commenting on the decision a leading article in the *British Medical Journal* (21st March 1942) put into words the thoughts of many. " It is a punishable offence to water milk and dilute the solids in it. Why, then, should it be thought praiseworthy to remove from the wheat berry the valuable minerals and vitamins which it contains ? " The national loaf became compulsory on 23rd March 1942.

In October 1944 the extraction of wheat was reduced to $82\frac{1}{2}$ per cent. The first reaction to this was that to reduce the extraction of flour, even if synthetic vitamins were to be added, was a further questionable procedure. It is always wise to assume that what has been discarded in milling cannot be fully replaced by the addition of a few essential nutrients, for the simple reason that we have no complete knowledge of what has been discarded. Fortification of white flour is not wholly favoured by Canadian medical men and scientists, who maintain that the wheat should be so milled that the protein, minerals and vitamins be retained in the flour. Some

interesting experiments in milling the wheat berry have been carried out in Canada. Using the vitamin B_1 content as an index of the nutritive quality of the flour obtained, Canadian scientists found that if the moisture content of the wheat milled was reduced from 15·5 to 12·5 per cent, the flour of 75 per cent extraction contained 363 I.U. vitamin B_1 per pound as compared with 254 I.U. in the white flour obtained by milling wheat with 15·5 per cent moisture.

The Distribution of Nutrients in the Wheat Berry.—The superiority of wheat over other cereals lies in its protein content, which, as McCance and Widdowson have shown, averages 13·62 in "hard" Manitoba wheat and 8·89 per cent in "soft" English wheat: the former has good, the latter rather poorer baking qualities (Table 29). Detailed examination of the wheat grain at the Cereals Research Station of the Ministry of Food has shown that the typical wheat grain consists of 12·3 per cent of bran, 83 per cent inner endosperm, 2 per cent outer endosperm, 1·2 per cent embryo and 1·5 per cent scutellum (see Fig. 31). The distribution of nutrients in the wheat grain is uneven but from Table 28 it will be seen how important as a source of vitamin B_1 is the scutellum, a thin shield of powdery

TABLE 28

NUTRIENT CONTENT OF DIFFERENT PARTS OF THE WHEAT GRAIN
(Moran and Drummond, *Lancet*, 1945, p. 698)

Factor	Whole Wheat	Clean Bran, including Aleurone Layer	Scutellum	Embryo	Outer Endosperm	Bulk Endosperm including outer Endosperm
Vitamin B_1 (I.U./g.)	1·2	1·6	55	3	1·5	0·2
Riboflavin (μg./g.)	1·6	5	15	15	1·8	0·7
Nicotinic acid (μg./g.)	50	250	60	60	150	22
Iron (mg./100 g.)	3·5	12	9	9	10	2·1
Approx. % weight	100	12	1·5	1	3	85·5

material lying between the embryo and the endosperm. If the scutellum, embryo and the outer layer of the endosperm be kept in the flour, most of the vitamins, minerals and proteins are retained.

It may be of some value at this point to state that the germ is not removed from the grain in the country from which it is imported, and that during the period in which the Ministry of Food was responsible for the production of an 85 per cent extraction flour, " no flour from which a proportion of the germ had been extracted was sold for any other than manufacturing purposes ". Flour for manufacturing purposes is officially designated " M " flour, and is mainly used for self-raising flour and for

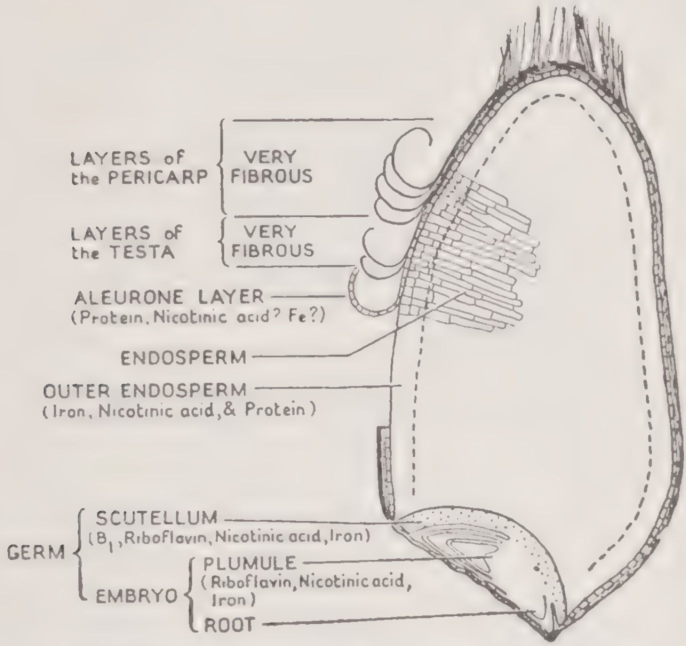

FIG. 31.—The distribution of nutrients in the wheat grain. (*Sir J. Drummond and Dr. T. Moran*). (*By courtesy of The Lancet.*)

making biscuits and confectionery goods. Such flour forms a very small percentage of the total flour used for human consumption.

From reports published regularly by the Scientific Adviser's Division of the Ministry of Food, one can follow the changes in the composition, nutritive value and quality of the flour from which our national wheatmeal loaf was made. In the early months of 1943 most of the flour was enriched with calcium carbonate, 7 oz. to the 280 lb. sack, but the mixing was not very uniform because of the poor flowing properties of the chalk. Bread experimentally produced was of good quality since in the laboratory it was baked under conditions in which water absorption, fermentation and temperature could be carefully controlled. Commercial baking does not apparently admit

Table 29

A. COMPOSITION OF MANITOBA AND ENGLISH WHEATS. (McCance *et al.*, *Biochem. Jour.*, 39, 215, 1945.)

(Results calculated on a 15 per cent moisture basis.)

Percentage extraction	Protein (N × 5·7)	Fat	Carbo-hydrate (as starch)	Cal./100 g.	Fibre (g./100 g.)	Aneurin (i.u./g.)	Ribo-flavin (μg./g.)	Nicotinic acid (μg./g.)	Calcium	Iron	Total P	Phytate P
	grams per 100 g.								mg. per 100 g.			
Manitoba												
100	13·62	2·49	63·0	328	2·15	1·18	1·7	55·0	27·6	3·81	350	242·0
85	13·57	1·70	67·2	339	0·33	0·92	1·0	13·3	18·5	—	188	96·1
80	13·22	1·43	68·8	341	0·13	0·65	0·8	11·0	15·4	—	139	63·4
75	13·05	1·32	69·5	342	0·10	0·29	0·7	9·6	13·1	—	109	36·8
70	12·77	1·16	70·0	341	Trace	0·22	0·7	8·4	12·8	—	97	30·0
42	11·80	0·86	71·2	341	Trace	0·09	0·5	7·0	11·1	—	82	14·0
English												
100	8·89	2·23	66·8	323	2·08	0·96	1·7	48·0	35·5	3·05	340	233·0
85	8·55	1·46	72·0	335	0·42	0·84	1·2	10·5	24·5	2·22	153	72·8
80	8·21	1·28	73·5	340	0·19	0·60	0·8	9·0	21·5	1·65	118	57·1
75	7·98	1·13	74·2	339	0·15	0·42	0·6	8·0	19·2	1·35	93	30·4
70	7·92	1·04	74·5	339	Trace	0·28	0·6	7·5	18·9	1·40	84	25·1
46	7·64	0·76	75·8	341	Trace	0·16	0·5	5·0	15·2	0·95	68	10·3

Energy values of protein, fat and carbohydrate taken as 4, 9 and 4 Cal./g. respectively.

of accurate control of all these factors, with the result that much of the bread was of only fair to good quality, the reasons being, incorrect fermentation of the dough, variations in water absorption, and insufficient baking. In Table 30, showing the results of analyses of commercial flours, the figures under 85 per cent extraction flour represent the average composition of the flour as stated in the fifth report covering samples received during January to June 1944. The figures in the 82½ per cent column are from commercially produced flours, data concerning which in fuller detail are to be found in the seventh report from the Scientific Adviser's Division of the Ministry of Food, 1945.

TABLE 30

ANALYSIS OF COMMERCIAL FLOURS

(Moran and Drummond, *Lancet*, i, 698, 1945 ; and McCance, *et al.*, *Biochem. J.*, 1945)

Factor	Rate of Extraction			
	100 per cent	85 per cent	82½ per cent	80 per cent
Vitamin B_1 (I.U./g.)	1·2	0·98	0·88	0·80
Riboflavin (μg./g.)	1·6	1·3	1·0	0·85
Nicotinic acid (μg./g.)	50	17	18	16
Iron (mg./100 g.)	3·5	2·07	1·94	1·65
Fibre (%)	—	0·50	0·31	0·21
Colour index	—	100	41	11
Protein (g./100 g.)	12·7	10·7	11·6	11·8

A detailed examination of Table 29 shows clearly the important relationship between the mineral and vitamin content of wheat and the degree of its extraction. Taking the content of wholemeal as 100, the loss in Manitoba flour of 85, 80, 75 and 70 per cent extraction is for vitamin B_1, 22, 45, 75 and 81 per cent ; for riboflavin, 41, 53, 59 and 59 per cent ; and for calcium, 33, 44, 52 and 53 per cent respectively. The nutritive value of the protein of flours of varying extraction has been examined by biological tests on rats in which the flour in question was the sole source of protein in an otherwise complete diet. In considering this matter Kon and Henry (1945) found that the difference in the biological value between 70 and 85 per cent extraction flour is just significant ; if, however, the values are recalculated in terms of nitrogen eaten, this

difference disappears since the digestibility of the 85 per cent is slightly less than that of the 70 per cent extraction flour. The same conclusions were arrived at by Kosterlitz and Campbell (1946), who assayed the biological value of the proteins by their effect on the cytoplasm of the liver. A suggestive but not significant difference was found if the values were calculated in terms of the nitrogen eaten; if, however, the smaller digestibility of the 85 per cent extraction flour was taken into account the difference became just significant. By determining the rate of growth of rats and their retention of nitrogen Chick *et al* (1946), found a slight difference in the nutritive value of the proteins in favour of the higher extraction flours, but concluded that the differences in the amount and quality of proteins in flours of different extractions are only of importance under conditions of poverty or food scarcity, when bread forms an unduly large proportion of the diet. The important differences in nutritive value between 100, 85 and 70 per cent extraction flours are in their content of vitamin B_1, riboflavin, nicotinic acid, calcium and iron.

That the high extraction flour would lead to a greater indigestibility of the loaf and cause a *significant loss* in both quantity and quality of protein available for human consumption is not founded on fact. As a result of the experiments of Krebs and Mellanby, 1942, it may be accepted that there is little difference between the digestibility of protein and the utilization of calories of 75 and 85 per cent extraction flour.

In discussing this question it is rather beside the point to state as an argument in favour of white bread that the baking of the national wheatmeal loaf, resulting in a loss of offal for the feeding of cows, means a reduction in the production of milk. The whole controversial question of the nutritive value of bread must be settled on its own merits. There need be no lack of offal for the feeding of cattle in peace-time; for the requirements of cows should place no obstacles in the way of milling even 90 per cent extraction flour for human consumption, provided adequate quantities of maize and protein cake are imported.

It would appear that we are now in the position where the application of scientific knowledge awaits further developments in milling techniques. To secure a flour of good nutritive value all the germ—certainly all the scutellum—and as much as possible of the outer endosperm layers adjacent to the bran,

must be retained in the final product of milling. As new milling methods are devised, more of these essential parts of the grain will appear in an 80 per cent extracted flour. The public should not forget that to retain the germ and the outer endosperm and at the same time reject just that amount of the bran to give a good and acceptable colour, requires a great deal of inventive skill on the part of the milling engineer.

It should no longer be a question of wholemeal bread versus white bread, nor of wholemeal versus enriched white flour, but, in view of the disastrous effects of white bread on generations of our people and the absurdity of removing essentials and returning but a few of their equivalents, the question should now be, can a relatively white loaf of good quality be made from flour, finely ground and containing the highest possible amount of the essential nutrients? At present the 85 per cent extraction flour is the best compromise, covering as it does both colour and nutritional value. Present knowledge merely renews the challenge to further achievement in science and technology.

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CHAPTER XII

MILK

The Nutritive Value of Milk.—Investigations of the chemical composition and nutritive value of milk and milk products and of the best means for their production for human use have been actively promoted for many years at Research Institutes, Marketing Boards and Veterinary Colleges in England and Scotland. The nutritive value of milk lies in the high biological value of its animal protein, its rich store of mineral salts, particularly calcium, and its substantial content of vitamins A and B (Table 31). Milk is excellently adapted to

TABLE 31

NUTRIENTS OF MILK, BUTTER AND CHEESE

Content per 100 *grams*

Nutrient	Protein g.	Fat g.	Carbohydrate g.	Vitamins A I.U.	Vitamins B_1 μg.	Vitamins D I.U.	Calcium mg.	Phosphorus mg.	Calories
Milk—									
human . .	1·3	3·7	6·5	—	—	—	30	—	67
cow, whole .	3·3	3·6	4·6	140	45	1·0	120	95	65
,, skimmed	3·4	0·1	4·8	—	45	—	124	98	33
,, powdered	25·6	26·7	35·6	1070	300	10·0	895	700	485
Cream, 18% .	2·5	18·0	4·5	—	—	—	—	—	200
,, 40% .	2·0	40·0	2·0	—	—	—	—	—	390
Butter (imported)	0·5	82·5	0	4000	—	80	15	—	750
Margarine .	0	85·3	0	2000	—	210	4	—	770
Cheese (Cheddar)	24·9	34·5	0	1300	30	15	810	—	410

the needs of the growing animal. Reference has already been made to the relation of the protein and mineral salt content of the maternal milk to the rate of growth in various animals. Its value as a food for children is indicated by the fact that, of the recommended daily dietary allowance of a 5-year-old child, 1 pint of summer milk supplies 75 per cent of riboflavin, 70 per cent of calcium, 38 per cent of protein, approximately 35 per

cent of vitamins A and B_1 and 25 per cent of the calories. Milk is the adult's best source of calcium, 1 pint contributing almost 88 per cent of the recommended daily requirement; of protein it supplies about 28 per cent and of riboflavin about 30 per cent (Kon, 1944). One pint of milk gives 350 to 380 calories, the figure varying with the fat content of the milk. While cow's milk is not the perfect food for the human infant, it forms the best foundation of the diet in infants, children and adolescents. Its fat is present in a finely divided or emulsified state and is thus easily assimilated; its sugar, lactose or milk sugar, does not cause fermentative disturbances as other sugars may do. The calorie value of milk is higher for the milk of the high fat breeds of cattle, Jerseys and Guernseys, than it is for the milk of Shorthorns, Ayrshires or Friesians. The feeding of cows is of special importance for upon it depends the richness of the vitamin A content of the milk. When grass and kale are abundant, as they are in the summer and autumn, milk is particularly rich in vitamin A, containing from 30 to 40 I.U. of the vitamin per gram of fat. In the winter and spring the vitamin A content may be as low as 10 to 20 I.U. per gram of fat. A noteworthy point is that, while the yellowness of cream is of no value in comparing milks from different breeds of cow, it is of value in comparing the milk from any particular breed. That Jersey and Guernsey cows produce milk the cream of which is so yellow, is due to their inability to convert carotene, which gives the colour, into vitamin A. Good feeding and care of milch cows is always repaid by a milk of high fat content, be they Jerseys or Ayrshires (Davies, 1944).

Milk is not to be regarded as a good source of vitamin C. Two factors are at play in the destruction of vitamin C in milk; they are oxygen and sunlight, for sunlight is responsible for the photochemical oxidation of vitamin C. The loss of vitamin C may be prevented by the removal of oxygen from the milk or by preventing the milk from being exposed to sunlight. The latter may be achieved by the delivery of milk in brown bottles or in cartons. The use of cartons would not only be of value in preserving vitamin C but would overcome one of the greatest difficulties in providing safe milk, namely the effective sterilization of bottles.

The amount of vitamin D in milk is very small; most of it is derived from the action of sunlight on the cow's hide.

In the U.S.A. great steps have been made in the enrichment of cow's milk by irradiation of the milk, addition of vitamin D concentrates to the milk, or feeding cows with irradiated yeast.

The Value of Milk in the Feeding of Children.—It has been established that " children from three to thirteen years of age should receive two pints of milk per day to ensure full growth and development ". Sherman, an American authority, has said that " milk greatly favours growth and development in youth, confers health and vigour throughout adult life and postpones old age. In no other way can the food habits now prevailing, especially in our cities, be so certainly and economically improved as by a more liberal use of good milk ".

One of the most convincing experiments on the value of milk for growing children was that carried out by Dr. Corry Mann in 1926. Several groups of boys, aged 7 to 11 years, were the subject of the experiment. One group was given the regular diet of the institute in which these boys lived; the others had supplements, and the results in terms of changes in height and weight over 1 year were noted (see Fig. 32). It was found that an increase in growth as measured by height and weight was produced by the addition of 1 pint of pasteurized whole milk per day. No effect on height was produced by the addition of caseinogen in amount equivalent to that contained in the milk, or of unvitaminized margarine in amount equivalent to the extra calories supplied by the pint of milk. With New Zealand butter in amount equivalent to the extra calories, improvement was noticed. The sugar given was the equivalent in calories of 1 pint of milk. Three-quarters of an ounce of watercress was given daily to one experimental group. Figure 32 shows graphically the results obtained. These results are important, emphasizing as they do the value of fat soluble vitamins and calcium in the diet, and the importance of at least 1 pint of fresh liquid milk in the daily diets of growing boys and girls.

The nutritional value of milk was heavily stressed 10 years ago in the first report of the Advisory Committee on Nutrition (Ministry of Health). " Within recent years ", to quote from the Report, " much experimental evidence has been brought forward which has shown that cows' milk is the most valuable food known for the promotion of growth and health in children." At that time, 1935, the calculated consumption

of liquid milk in this country was just under 0·4 pint per head per day, an average figure which is less revealing than the figures indicating the range of consumption. According to Sir John Orr, the lowest income group in his 1935 survey consumed 1·1 pints, the highest approximately 5·4 pints per head

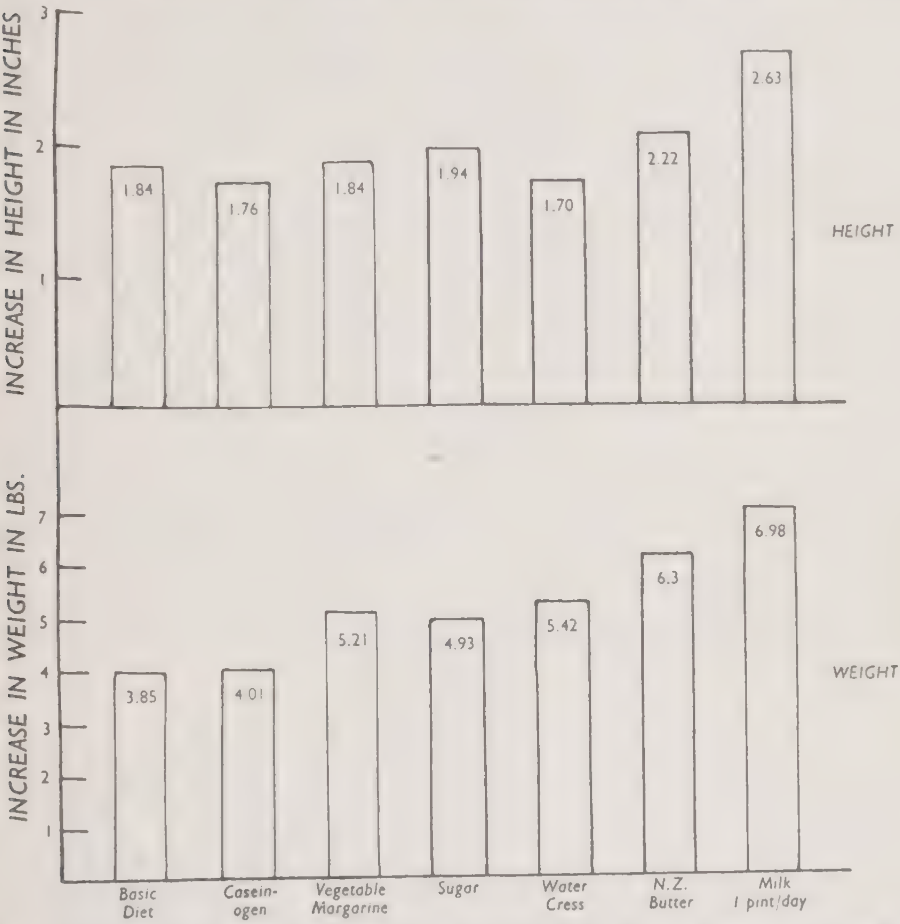

FIG. 32.—Diagrammatic presentation of increase in height and weight of boys in one year on various supplements to a basic diet. [*Drawn from data of Dr. H. C. Corry Mann, O.B.E.*]

per week, the average being 3·1 pints per head per week, i.e. 0·44 pint per head per day. These and other facts stirred the Ministry of Agriculture and the Milk Marketing Board to develop schemes for the supply of milk to children in schools and to mothers and children at home. From 1933 to 1943 milk production increased by 30 per cent and liquid consumption by 55 per cent. Since the beginning of the war (1939–45), and as

part of the policy of the Ministry of Food, a great improvement in milk distribution has taken place. In 1933, 855 million gallons of milk were produced; in 1943, 1110 million gallons, in 1944 1180 million gallons, and in 1945, 1207 million gallons. From 1933 to 1943 sales of liquid milk rose from 643 to 1000 million gallons. The National Milk Scheme provided one-third of a pint of milk at the cost of ½d. for all school children who cared to avail themselves of it, and 1 pint of milk daily for all nursing mothers and children under 5 years of age, either free or at a reduced price. These two schemes to-day account for about 15 per cent of the total liquid milk consumption. In the interests of national health, these schemes should never be allowed to lapse. Other schemes of milk priority distribution—to invalids, the sick, expectant mothers and adolescents—also helped to increase the consumption of milk. In view of the activity of the Ministries of Food, Health and Agriculture, and the milk propaganda campaigns, it is not surprising that the increase in liquid milk consumption from 1935 to 1944 was approximately 50 per cent. An enlightened and progressive nutrition policy would aim at supplying the people of this country with not less than 0·75 pint of liquid milk per head of the population per day, with provision within this average for the adequate supply of milk to expectant and nursing mothers, children and old people.

THE PASTEURIZATION OF MILK

Pasteurization of milk began on a commercial scale in the large towns of this country about the beginning of the present century. Its whole object was to destroy the common pathogenic organisms which occur in raw milk and thus render it safe for human consumption. The original method was to heat milk to about 170° F. for a very short period and to cool it rapidly: this was essentially a "flash" or short time high temperature process, but it was entirely uncontrolled with regard to time. The reason behind the introduction of this public health action was the knowledge that living tubercle germs in milk was the cause of certain types of non-pulmonary tuberculosis from which, as shown by the statistical reports issued by the Registrar-General, too many deaths occurred.

Table 32 is worthy of some consideration. The human type of tuberculosis is derived exclusively from man and

Table 32

CALCULATED NUMBER OF DEATHS IN ENGLAND AND WALES AND SCOTLAND IN 1937, DUE TO INFECTION WITH THE BOVINE TYPE OF TUBERCLE BACILLUS, ALL AGES.

(From G. S. Wilson, *The Pasteurization of Milk*, 1942.)

	England			Scotland		
	Total Deaths	Bovine Deaths	Per cent Bovine	Total Deaths	Bovine Deaths	Per cent Bovine
Respiratory . . .	23,970	336	1·4	2,791	151	5·4
Central nervous system .	1,796	421	—	374	103	—
Intestines, peritoneum . .	676	554	82	159	92	—
Bones and joints . . .	569	135	23	83	19	23
Lymphatic system, bronchial and glands, etc. . .	432	92	21	57	17	30
Disseminated . . .	1,086	65	6	199	22	11
	28,529	1,603	5·6	3,663	404	11·0

Total for U.K.—deaths	= 32,192	Total bovine deaths	= 2,007
Bovine deaths	= 2,007	Total bovine respiratory deaths, i.e. pulmonary T.B. of bovine origin	= 487
Percentage bovine	= 6·2	Pulmonary bovine T.B. as a percentage of total bovine T.B. deaths	= 24

infection is mainly by way of the respiratory organs. The bovine type of tuberculosis is derived from cattle and generally infection of man is by way of the alimentary tract. The number of deaths due to bovine tuberculosis is arrived at by indirect methods, because it is not possible to distinguish clinically between tuberculosis of human and bovine origin. The methods, to which no reference can be made here, are substantially accurate and they show that bovine tubercle bacilli caused the deaths of 2007 people in this country in the year 1937. Of these 2007 people, 487 (24 per cent) died from pulmonary tuberculosis. In the North-East rural region of Scotland the incidence of pulmonary tuberculosis of *bovine* origin was 8·5 per cent in 1937; in the Middle and South of Scotland, 4·6 per cent; while in England the regional percentage incidence varied from 0·56 to 1·60. To relieve the depressing

picture, look at the figures in Table 33 for 1921 and 1938; they show that there has been a steady fall, during a period of 17

TABLE 33

THE FIGURES FOR NON-PULMONARY T.B. DEATHS FOR 1921 AND 1938

	Intestinal and Peritoneal Tuberculosis	Spinal Tuberculosis	Tuberculosis of Bones and Joints	Tuberculous Glands	Total Deaths from non-pulmonary T.B.	Death-rate per mill. of Population
Number of deaths—						
In 1921 . .	2,147	667	417	123	3,354	88
,, 1938 . .	595	319	175	45	1,134	25

years, in those categories in which a large proportion of the cases is due to tubercle bacilli in milk. The fall—88 to 25 per million—represents a reduction of 72 per cent in the death-rate from the types of tuberculosis listed. The death-rate from all other forms of tuberculosis fell from 1037 to 607 per million, a reduction of 42 per cent. Most, but not all, of the cases of tuberculosis of the respiratory and central nervous systems are the result of infection from human sources. It is, of course, difficult to say to what extent the reduction in mortality is due to pasteurization or cleanliness on the part of farm and transport personnel. It may not be known generally that calves and pigs are very susceptible to infection by the bovine tubercle bacilli in milk, whey, skim milk and other products of dairy farming. Milk is an excellent medium for the growth of tubercle bacilli, and since about one-third of the deaths from tuberculosis in children under 5 years of age is due to the bovine organism, and a greater number than those who die suffer many disabilities on account of it, surely it is reasonable to demand that milk should be made entirely safe for children. Cattle are also susceptible to the organism *Brucella abortus*, which causes undulant fever, a fever not uncommon in man. In milk there are found numerous colonies of pyogenic streptococci which play a prominent part in milk-borne epidemic disease. These organisms, which cause tonsillitis, scarlet fever, epidemic sore throat, erysipelas and other septicæmic conditions are found in the udder of the cow. Many of these

bovine streptococcal infections (*hæmolytic streptococci*) are of human origin.

It is clear that there is a milk problem, which is bound up on the one hand with the nutritional condition of young and old but particularly of the young, and on the other with the improvement of the breeding of dairy cattle. It is true that 6 to 7 per cent of the farms in this country produce tubercle-containing milk, about 40 per cent of milch cows react to the tuberculin test and tubercle bacilli are present in the milk of 1 in every 200 milch cows. There are approximately $3\frac{1}{4}$ million dairy cattle in this country. The elimination of tuberculosis in cattle can only be carried out satisfactorily by testing all animals for tubercle, removing or destroying all which react to the test, and breeding from animals free from the disease. In the U.S.A., between 1917 and 1940, the incidence of tuberculosis in cattle was reduced from 4 to 0·5 per cent. The reasons for the production of safe milk, milk free from pathogenic organisms, are numerous and are assuredly well founded. The methods by which the desired aim may be attained are not technically difficult, they are: the elimination of infectious diseases from animals and from human personnel, and the destruction of pathogenic organisms in milk. Those who wish to be fully informed on these methods should consult *The Pasteurization of Milk*, by Professor G. S. Wilson, and *Bacteria in Relation to the Milk Supply*, by C. H. Chalmers.

METHODS FOR PASTEURIZATION OF MILK

The Holder Method.—Most of the milk in this country is pasteurized by the "holder method", which consists in heating the milk to not less than 145° and not over 150° F., keeping it at this temperature for 30 minutes and then cooling quickly to a temperature of 50° F. The nutritional losses occasioned are about 20 per cent of vitamin C, a loss mostly due to exposure to light and not to the process *per se*, and 10 per cent of vitamin B_1. Certain enzymes are destroyed, particularly the enzyme phosphatase, the absence of which is used as a test of efficient pasteurization. These enzyme losses are, as far as we know, without nutritional significance. Milk pasteurized by the Holder method will keep for 48 hours at 70° F. and for 72 hours at 60° F. When the milk has been

bottled its keeping properties may be much reduced : bottles, unless sterilized, may be responsible for rapid souring of the milk.

The High Temperature Short Time [H.T.S.T.] Method.—This process, with accurate control of temperature, time and milk flow, has proved to be very satisfactory for pasteurizing milk. The milk is heated to a temperature of 163° F. and held for a period of 15 seconds. With the use of thermocouples, accurate flow control device, a continual record of temperature and a flow diversion valve for diverting any milk which has not been correctly heated, the method can be made almost entirely automatic. The film of milk as it passes over the heater is not more than 0·01 inch thick, thus ensuring that every particle of milk is heated. The milk is rapidly cooled to a temperature of 40° F. The details of the method are diagrammatically shown in Fig. 33. A typical installation, capable of handling 3000 gallons of milk per hour, is shown in Fig. 34. The temperature and time of exposure are ample to kill all tubercle bacilli in the milk treated by this method. The H.T.S.T. method was first used in this country in 1923 and was officially recognized as a

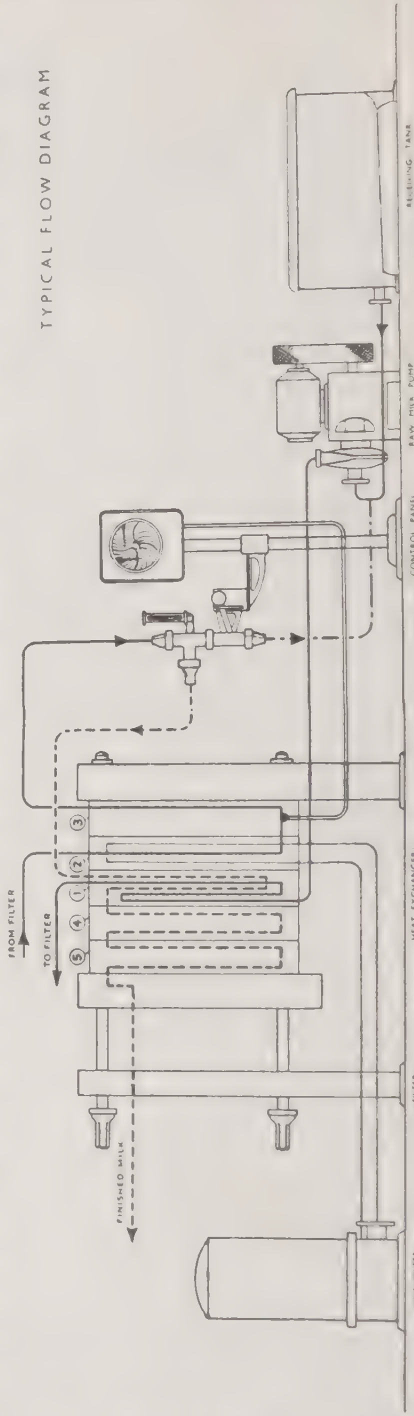

FIG. 33.—Diagrammatic representation of the milk flow in the aluminium plant and vessel short time high temperature pasteurization plant. [*By courtesy Aluminium Plant and Vessel Co., Ltd.*]

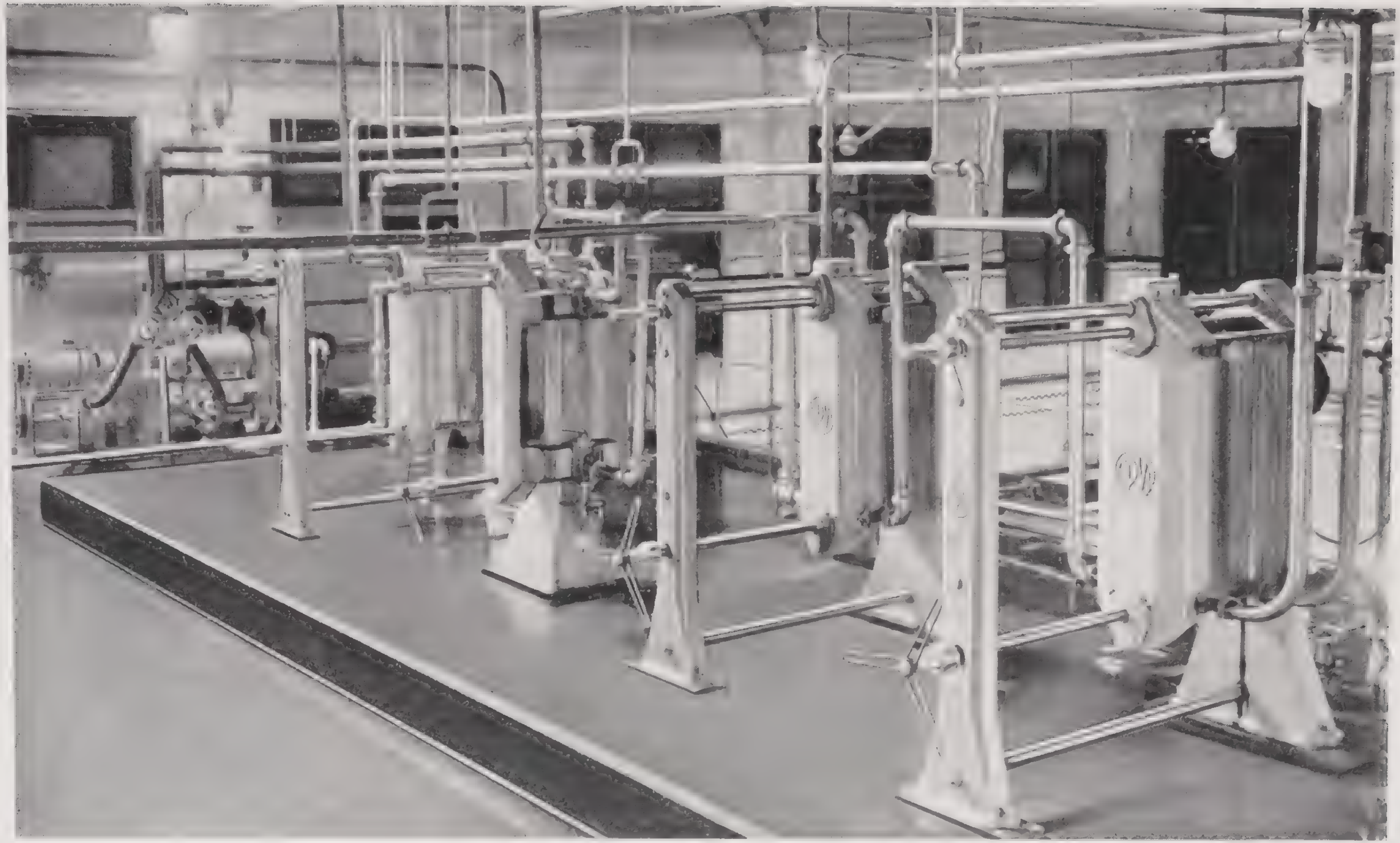

FIG. 34.—Showing A.P.V. short time high temperature pasteurizing plant, Aberdeen, capacity 3000 gallons of milk per hour.

[*To face page* 180.

statutory process in 1941. Its great advantages are economy of plant, floor space and time. It is a method of precision based on sound scientific principles. The destruction of vitamins C and B_1 is practically the same as with the Holder process. In all pasteurization methods, the milk is rapidly cooled to prevent the multiplication of heat-resisting non-pathogenic organisms. The efficiency of these methods is tested by determining whether the enzyme, phosphatase, has been destroyed. To destroy the enzyme, the temperature must be slightly higher than that required to kill the tubercle bacilli.

Sterilized Milk.—There is a growing demand for this type of milk. In its preparation it is heated to 212° F. and often higher for varying lengths of time. Sterilized milk tastes and keeps well; vitamin C and B_1 are destroyed to one-half and one-third of their original content in raw milk. The biological value of the proteins is said to be but slightly reduced.

" In Bottle " pasteurization.—In this method milk at 147° F. is filled into sterilized bottles, and the milk held at 145° F. for 30 minutes and then cooled. The method is ideal, but it requires extensive plant and much floor space. It would, however, guarantee the delivery of a milk safe from all pathogenic organisms.

OTHER HEAT TREATMENT PROCESSES

Dried Milk. (*a*) **The Spray or Atomizer Process.**—In this process precondensed milk is sprayed in a current of heated air in a specially designed chamber. Spray dried milk is almost completely soluble in water and is therefore easily reconstituted; the nutrient losses are as for the Holder process, namely, protein 5 per cent, vitamin B_1 10 per cent and vitamin C 20 per cent.

(*b*) **The Roller, Drum or Film Process.**—Roller dried milk, produced by heating a thin film of milk on revolving cylinders, heated internally by steam, is less soluble, and suffers slightly greater destruction of its vitamins and protein, than does spray dried milk. The milk may be dried at barometric pressure by exposure to a high temperature, or *in vacuo* at a much lower temperature. Most of the dried milk in this country is prepared by the roller process. The roller dried powders containing fat (full cream and part cream) appear

to keep better than do the spray dried. National dried milk prepared in the U.K. is roller dried: there are two varieties, full cream with 26 per cent of fat and half cream with 16·5 per cent of fat.

Full cream dried milks keep well if hermetically sealed and kept under an inert gas.

Dried skim milks, where much of the fat has been removed to enhance the keeping quality of the product, are very nutritious for all except infants. With the absence of the fat, a valuable nutrient is, of course, missing, but nevertheless the milk still contains its quota of animal protein, mineral salts, riboflavin, etc.

Condensed Milks.—The thick, unsweetened variety is evaporated *in vacuo* at a low temperature, it is then placed in tins, sealed and sterilized at a temperature of 240° F. Vitamin C is reduced 60 per cent or more: the biological value of the proteins is definitely but not greatly reduced. If the milk be sweetened by the addition of cane sugar, it is then not exposed to such high temperatures as the unsweetened article. Cane sugar, at a final concentration of about 40 per cent, effectively checks all bacterial growth and a temperature of 212° F. (boiling point) is quite sufficient for sterilization of the preparation. The amount of nutrients remains practically the same as that of the raw fresh milk. Dried milk is concentrated to about $7\frac{1}{2}$ times, evaporated or condensed milk to about $2\frac{3}{4}$ times the strength of the original milk.

With these methods for the production of safe milk, it is somewhat strange that full accord on the subject of pasteurization has not been reached. It is nevertheless true that for many, heat treated liquid milk is unacceptable. In 1942 Professor H. D. Kay, Director of the National Institute for Research in Dairying, Reading, declared that "the pasteurization bogey is now satisfactorily laid". "In the near future it will almost certainly be a national requirement that all milk sold for liquid consumption shall either be effectively pasteurized or shall be from disease free animals."

MILK DESIGNATIONS

Of the milk-borne diseases which call for elimination in the interests of human welfare and agricultural economy, tuberculosis and brucella infection are the most important. Upon

their successful control or elimination the solution of the problems of milk production largely depend. In order to improve the quality of the nation's milk supply veterinary inspection is regulated and milk is produced under several designations: e.g., tuberculin tested (T.T.), accredited, pasteurized, certified. These designations differ somewhat for England and Wales, and for Scotland. They are as follows:

England and Wales.—Ministry of Health: Milk (Special Designations) Order 1936–43.

Tuberculin Tested Milk is milk from cows which have passed a veterinary examination and a tuberculin test; it is bottled on the farm or elsewhere and it may be raw or pasteurized. If bottled on the farm, it may be described on the bottle caps or cartons as *Tuberculin Tested Milk* (*Certified*). Coliform bacilli must not be present in 0·01 millilitre. If it is pasteurized, it is described as *Tuberculin Tested Milk* (*Pasteurized*). Such milk must not contain more than 30,000 bacteria per millilitre.

Accredited Milk is raw milk from cows which have passed a veterinary examination: it is bottled on the farm or elsewhere. It must satisfy the same bacteriological tests as raw tuberculin tested milk. It must contain no coliform bacilli in 0·01 millilitre.

Pasteurized Milk is milk which has been retained at a temperature of 145° to 150° F. for at least 30 minutes, and does not contain more than 100,000 bacteria per millilitre. Under a Milk Special Designation Regulation dated July 1941, the High Temperature Short Time Method was officially recognized.

It is unlawful for any person to use any of these designations unless he holds a licence from the appropriate Licensing Authority authorizing him to do so. All milk produced under these designations must be kept apart from all other milk at all times unless it is in sealed containers.

Scotland.—Department of Health for Scotland. Milk (Special Designations) Orders (Scotland) 1936 to 1944.

Certified Milk is milk from a tubercle-free herd, clinically examined and which has passed a tuberculin test. *It must be bottled on the farm* in bottles not exceeding a capacity of 1 quart *and can be sold only if it has not been heat treated.* The bottles must have been sterilized by steam; must be tightly closed and securely fastened with a hooded cap. The cap must bear the name of the producer, the date and the words " certified

milk ". *The milk must contain at least* 3·5 *per cent butter fat* and must not contain more than 30,000 bacteria per millilitre and no coliform bacillus in 0·1 millilitre. It must be cooled on the premises to 50° F. immediately after production.

Tuberculin Tested Milk is milk from a tubercle-free herd which periodically passes a clinical veterinary examination and a tuberculin test. It may be bottled on the farm or elsewhere. If not pasteurized, it must be cooled to 60° F. immediately after milking, must not contain more than 200,000 bacteria per millilitre and no coli bacilli in 0·01 millilitre. If pasteurized, it must be described as *Tuberculin Tested* (*Pasteurized*). It must contain at least 3·5 per cent of butter fat and must not contain more than 30,000 bacteria per millilitre and no coliform bacillus in 0·1 millilitre. It must be cooled immediately on production to 50° F.

Standard Milk is milk from a herd which passes a clinical veterinary examination not less than three times a year: it must be bottled on the farm or elsewhere and *can be sold only if it has not been heat treated.* It must contain at least 3·5 per cent butter fat and must not contain 200,000 bacteria per millilitre and no coliform bacillus in 0·01 millilitre. Regulations for bottling are similar to those for T.T. milk.

Pasteurized Milk is milk heat-treated by either the Holder or the H.T.S.T. methods as previously described. The milk upon production must be cooled to 50° F. (later regulation 60° F.). It must not contain more than 30,000 bacteria per millilitre and must not contain coliform bacillus in 0·01 millilitre. The milk must not be pasteurized more than once, and all storage vessels and bottles must be labelled "*Pasteurized Milk*".

To produce any of these designated milks a producer must hold the appropriate licence from a local Authority. The licence applies to one grade of milk and one establishment at or from which it is sold.

The milk (Special Designations) Amendment Order (Scotland), 1944, creates a new designation namely "*Heat Treated*," and removes the ban on heating pasteurized milk more than once. The temperature must not be raised above 173° F. and the milk must be cooled to 50° F.

Under Defence Regulation 55 G, two tests are prescribed: one the Phosphatase Test determines the efficiency of the heat

treatment in any particular case, the other, the Methylene Blue Test serves as an indication of keeping quality. For fuller information concerning Rules, Amendments and prescribed Tests reference must be made to the Statutory Rules and Orders published by H.M. Stationery Office, London.

DAIRY HERDS—SPECIAL EXAMINATIONS

It will be readily understood that certain conditions must apply to the grant of a licence to sell Certified and Tuberculin Tested Milks. The conditions affect the herds from which the milk under these various designations is produced.

Tuberculin Tested Herds.—(*a*) *Veterinary. Examination.*—Every animal in the herd must pass a clinical veterinary examination within one month before the date of application for a licence and thereafter every six months.

(*b*) *Tuberculin Test.*—If the herd is not on the Register of Attested Herds kept by the Minister of Agriculture and Fisheries (England) every animal in the herd must pass a tuberculin test within one month before the date of application for the licence and thereafter at intervals of not less than two and not more than six months. An animal born in the herd must be submitted to the tuberculin test before it reaches the age of twelve months. In Scotland, if after two tests within the herd the animal shows no reaction to the test, it is tested only at yearly intervals. If any animal reacts to the tuberculin test, it is immediately removed from the herd. These tuberculin tested herds must be isolated from all other cattle or swine.

Attested Herds.—In 1937 the Ministry of Agriculture and Fisheries introduced the Tuberculosis (Attested Herds) Scheme (England and Wales) the aim of which was to encourage the voluntary attestation of herds on the basis of the tuberculin test ; to build up in certain areas herds where the majority was free from infection ; to test compulsorily animals in these areas and to remove or destroy all animals which reacted to the test.

The herds must pass two tuberculin tests at an interval of not less than 60 days and not more than 12 months without reactors being found. Rules and regulations are also laid down for the management of the herds and the hygienic handling of the milk.

The scheme has progressed slowly: by 1939 there were in England and Wales less than 5000 attested herds, representing about 3 per cent of the dairy herds. In Scotland progress has been more satisfactory and large groups of farms are now stocked with herds which have passed the tuberculin test. These herds are concentrated chiefly in the S.W. and N.E. of Scotland. Areas in which these precautions have been taken may be declared attested areas (Defence Regulations 55 G, 1934). At 31st December, 1945, there were 5617 attested, herds in Scotland.

Accredited Herds.—These are herds which are examined clinically by a veterinary surgeon at least once a year where the milk is heat-treated and once every three months where it is not. The cleanliness of buildings and milking arrangements and the sterilization of utensils must be to the satisfaction of the appropriate local authority. The milk is judged as to its cleanliness by suitable laboratory tests. Milk (Special Designations) Regulations, 1943, Circular 2879.

The attestation scheme is costly, but the cost, in the form of financial aid from the Ministry of Agriculture and financial remuneration from the Milk Marketing Board (an extra 2½d. per gallon of milk produced and 2d. from the distributor who buys the milk) should deter none from supporting this scheme which is the very basis of the milk problem—the eradication of diseased animals from milking herds. In so far as the declaration of areas is concerned, it is curious that this has not yet been put into operation. The scheme, so highly approved by scientific and medical opinion, has not fully materialized. The milks have been designated for some time, the specific areas still await their designation.

There are, however, not a few, with expert knowledge in this matter, who do not favour the production of "accredited milk". It will be noted that accredited cows are not tuberculin tested. A Medical Officer of Health can stop the selling of milk infected with any human notifiable infectious disease; he cannot, however, except in the case of a school under his direct control, stop the selling of milk containing the germs of tubercle and undulant fever. It is, however, an offence knowingly to sell such milk. When tubercle bacilli are found in milk, the M.O.H. notifies the Ministry of Agriculture who proceed to trace and remove the offending cow. Remembering that a

great deal of milk is pooled and that it comes from numerous farms, one will be conscious of a certain difficulty in finding the errant cow whose milk, until found, will continue to supply the virulent organism to an uninformed community. Too great stress must not be laid on what may be regarded as exceptional, but an instance has been recorded where three human cases of undulant fever were traced to the same producer-retailer of tuberculin tested milk. The producer, doubtlessly proud of the cleanliness of his byres and cows, assured by the possession of a tuberculin tested herd, refused to have his milk temporarily pasteurized and yet on his farm contagious abortion was rife.

Another point worth a moment's thought is, that while a " T.T." producer must not have any tuberculin reacting cows in his herd, he is not compelled to destroy the solitary " reactor " when it is discovered, indeed he may quite legitimately or legally sell it to his nearest " non T.T." neighbour—and half or more of his neighbour's herd may be made up of beasts of this sort and the milk not lacking in the bacillus of tuberculosis. There is, as yet, no means of legislating for the possible failings of the human element in milk production.

Despite a high mortality, chronic invalidism and crippling arising from bovine tuberculosis, large numbers of the people in England, Scotland and Wales are still exposed to all the dangers of raw milk. The eradication of tuberculosis from United Kingdom herds is the very basis of the problem. But the production of safe milk from safe cows will necessitate vast changes in the administration of many farms throughout the land. Farmers must be encouraged to equip their farms with modern appliances, to install adequate water and electric power, and generally helped to train their farm personnel in the techniques of animal hygiene. When this is done, veterinary and medical officers will be in a stronger position than they have been in the past to criticize, advise and, when necessary, to take action. It must never be assumed that cleanliness means safety in the production of milk. It is certainly a long step towards the desired aim, but until all tuberculin tested milch cows remain negative to the test, are free from the organisms of undulant fever and all milk is bottled immediately upon delivery, by sterilized apparatus from the udder, then pasteurization must not be discarded. In arriving at a fair judgment on the pasteurization of milk, one must be careful not to argue

from the particular to the general. Undoubtedly many parts of the country, particularly rural areas, see little of milk-borne epidemics, and are supplied with raw milk of a high standard of cleanliness, but many are not so favoured. The problems of the rapid transportation of milk to and its delivery in large cities will remain problems until the " milk-refrigerator car " has become a reality. Clean milk is still not safe milk ; the bacilli of tubercle, dysentery, epidemic sore throat, etc., can still be carried by clean milk, as the figures published by the L.C.C. prove. Interesting in this connection was the action of American military authorities in not allowing American troops in this country to drink milk which was not obtained from T.T. herds and had not also been pasteurized.

At the present time, difficulties human, as well as bovine, stand firmly in the way of rapid progress. Again the questions arise ; should people be permitted to buy non-nutritious and unwholesome food ? Should the Government, ignoring all scientific knowledge, allow food of whatever grade of inferiority to be placed in the nation's larder ? The answer would appear to be an unqualified negative. But be it what it may, it is now axiomatic that the health and the well-being of the nation is the responsibility not only of the Government but of the people. Perhaps

> " from ignorance our comfort grows
> the only wretched are the wise ",

perhaps, if we are strict about the cleanliness of milk, we need not bother about " the foolishness of pasteurization ", but, perhaps, with a little more agricultural, medical and scientific knowledge on the matter, we may change our opinion. To talk about " the foolishness of pasteurization " is but to show ignorance of the whole milk problem ; to state that " it is a necessary evil " is somewhat beside the mark. Surely nothing that is necessary for the improvement and maintenance of the health of a nation can be regarded as evil. Pasteurization is necessary, not that by using it the dangers of milk may be ignored, but that knowing the dangerous possibilities of milk, the community may be safeguarded while the problems of its safe production are being solved.

The Cream Line in Pasteurized Milk.—The most frequent criticism levelled against pasteurized milk, particularly the H.T.S.T. process, is that, because of the reduction of the

cream line, some of the cream has been removed. The apparent loss of cream is due to the change in the physical aggregation of the fat globules produced by heating and is not indicative of any diminution in the amount or alteration in the nutritive value of the fat.

Lactic Acid Organisms in Milk.—It is well known that heated milk does not sour so readily as fresh milk. Souring is due to the presence of lactic acid bacteria found in fresh milk by contamination after the milk has been obtained from the cow. If the lactic acid bacteria be allowed to proliferate, the milk may become sufficiently acid to bring about the destruction of pathogenic organisms in the milk. The milk will also become sour due to the formation of lactic acid from lactose by bacterial action. Pasteurized milk in which the lactic acid bacteria have been largely destroyed does not readily sour on standing, but like fresh milk, if left uncovered and uncooled, will become unpleasant. This is due to changes in the nature of the protein of the milk. When milk curdles, it indicates that the amount of acid formed has been sufficient to precipitate the milk protein—caseinogen.

Upon the addition of rennin (chymase) to milk, it clots or coagulates ; the nature of this change is doubtful but it is probable that an insoluble calcium salt of casein is formed. When this action takes place, a jelly or junket is formed, the clot shrinks, becomes entangled with the fat of the milk, thereby forming the curd or curds and subsequently expresses a yellowish fluid which is called whey. The distinction between the acid curdling and the enzymatic clotting will be noted.

Pasteurized milk, unless kept for several hours, clots with rennin just as readily as the fresh article : if it did not, it could not be used in the making of cheese. Milk which has been boiled will not clot with rennin. Milk pasteurized by licensed methods will behave as fresh milk, provided there is no greater delay in using it than there normally is with fresh liquid milk.

The Cleaning and Sterilization of Milk Bottles.—The problem of the bacteriologically clean milk bottle is a very real one. Suggestions to replace bottles by cartons have been made ; this, however, will not easily be accomplished because much capital in the dairying industry is sunk in bottling plants. Given a carton which could be sterilized, closed with a cap, and which would not be too readily affected by external

condensation on the outer surface of the carton containing cold milk, there should be little difficulty in modifying the present bottling methods so that by piercing the cap of the carton it may be filled with pasteurized milk and the aperture immediately closed. The carton should then be placed in a refrigerator, delivered cold and discarded when empty. The danger of using imperfectly sterilized bottles would thus be avoided, and not only would the noise occasioned by the use of bottles become a fading memory, but the disadvantages of their fragility would disappear.

Much careful work has been undertaken in order to determine how best to clean and sterilize milk bottles. Hand washing, steam sterilization, cleansing by detergents, have all been examined. The first has been condemned, the second proved not to be very satisfactory, the last, followed by rinsing with hot water and external cooling of the bottle, has been found the most satisfactory. Several machines of new design are in use in which the strength of the detergent is well controlled, the final washing of the bottle effective in removing the detergent, and the external cooling adequate. They are based on comparatively recent surveys of bottle washing plants undertaken to determine the most effective method for cleaning and sterilizing milk bottles. In this country the most important of these surveys was carried out by Hobbs and Wilson, a summary of whose report to the Ministry of Health is to be found in the *Journal of Hygiene* (1943). They have made it quite clear that the two main factors concerned in the destruction of bacteria are the concentration and the temperature of the caustic detergent used in cleaning the bottles. The required result can be attained by using either a weak caustic solution (1·46 %) at a high temperature (160° F.) or a strong solution (2·44 %) at a lower temperature (120° F.), the time of exposure being 1 minute. If the time of exposure be 4 minutes the strength of the solutions can be halved. The detergent solution used in bottle washing machines contains, in addition to the caustic soda, sodium metasilicate, sodium hexametaphosphate, trisodium phosphate and sodium carbonate made up in such a way as to give a proper balance between the various qualities of fat saponification and dispersive power. Bottles emerging from the detergent section in properly operated plants are virtually sterile. The subsequent rinsing processes

expose them to bacteriological recontamination. Contamination may be avoided by the addition of chlorine to the rinse water, a procedure not advocated by Hobbs and Wilson since it " is likely to degenerate into an excuse for dirtiness ". These authors recommend that to remove the detergent the bottles should be internally sprayed in the inverted position with *hot* water at a temperature high enough to inhibit bacterial growth, cooled by *external* rinses of water progressively decreasing in temperature and finally cooled by a rinse with cold mains water both internally and externally. The bottles should then be allowed time to drain effectively, a wide neck pint bottle for example, should drain for 1 minute. The bottles at a temperature of not more than 68° F. should be immediately filled with milk and closed with a press-in disc cap and a hooded cap. The ordinary custom of using a press-in disc cap without any further covering is to be condemned, for it leaves the top of the bottle open to contamination from both human and animal sources. Modern bottle washing machines with close attention to strength and temperature of detergents, cleaned daily with 1 per cent caustic soda, thoroughly washed with cold mains water and having all jets, manifolds and distributor bands scrupulously cleaned after each run, will produce bottles of a high degree of bacterial cleanliness.

It has been suggested that milk be pasteurized in the bottle. This is a sound suggestion. It has also been suggested that if milk were hygienically delivered direct from the tuberculin tested cow by sterilized apparatus to a sterilized bottle or carton, it would not require to be pasteurized. Provided milk bottles are cleaned by the modern methods referred to the milk would be tolerably safe and clean and would have good keeping properties, but, in contrast to the " in the bottle " pasteurized milk, it could not be guaranteed free from pathogenic organisms.

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CHAPTER XIII

PROTEIN RICH FOODS

CHEESE : EGGS : MEAT : FISH

Cheese.—Cheese is a very concentrated protein food. It is prepared by the coagulation or clotting of milk by means of rennin, the proteolytic enzyme contained in the mucous membrane of the fourth stomach of the calf. Cheese making, one of the primitive arts of husbandry, was probably introduced into this country by the Romans. In mediæval times the making of cheese was one of the chief duties of the farmer's wife, both whole and skim milk being used. In the seventeenth and eighteenth centuries many English counties, Somerset, Shropshire, Kent, Cheshire, to mention but a few, were known for their cheeses. Stilton cheese is known as such from the fact that it was supplied to the Bell Inn at Stilton in Huntingdonshire on the Great North Road, by those who made it at Melton in Leicestershire.

Composition of Cheese.—Table 34 shows the percentage composition of various well-known cheeses: the difference in protein and fat content of the hard in contrast to the soft or cream cheeses should be noted. Containing not only the protein and fat but most of the calcium and phosphorus and the fat soluble vitamins of the milk from which it is prepared, cheese is a most valuable food. The fat content of cheese depends upon whether it is made from whole milk, skim milk or milk to which cream has been added (*cp.* Stilton to which extra cream is added). The English-made cheeses, Stilton, Cheddar, Cheshire, St. Ivel and others have all gained a high reputation. In view of the quality of the English cheese, it is perhaps unfortunate that home production forms such a small proportion of the total amount consumed in this country. In 1938 the total consumption of cheese per head per week in the United Kingdom was 2·7 oz., and of this only 0·6 oz. was home produced. The great and increasing demand for fresh liquid milk will tend to restrict the home production of cheese for some considerable time. It is hoped, however, that the

variety of cheeses previously obtaining, due to imports from New Zealand, Canada, Holland, France and Italy, will return in even greater strength in the future. Cheese, containing in concentrated form most of the nutritive elements of milk and having excellent keeping qualities, should hold a far more important place in the diet of the people than it does at present.

TABLE 34

THE COMPOSITION OF CHEESE

(McCance and Widdowson, *M.R.C. Sp. Rep. Series* No. 235)

Cheese	Protein g./100 g.	Fat g./100 g.	Calories per 100 g.	Calcium mg./100 g.	Iron mg./100 g.	Phosphorus mg./100 g.
Cheddar . .	24·9	34·5	423	810·0	0·57	545
Cream . .	3·2	86·0	813	29·6	0·14	44
Dutch . .	28·1	16·8	271	900·0	0·78	478
Gorgonzola . .	24·8	31·1	392	540	0·50	375
Gruyère . .	36·8	33·4	461	1080	0·26	698
Parmesan . .	34·4	29·7	417	1220	0·37	772
St. Ivel . .	23·1	30·5	379	483	0·72	375
Stilton . .	25·1	40·0	475	362	0·46	304

In 1935 the League of Nations standard for cheese consumption was given as 6·5 oz. per head per week. The Stiebling standard (U.S.A.) is 5·5 oz., which is at least three times the average American consumption rate. The consumption in this country in 1938 was 2·7 oz. per head per week. To-day, after six years of war during which they have existed on a minimal and monotonous diet, the people of the United Kingdom still find, apart from those who require special rations, that a ration of 3 oz. of cheese per head per week is ample. The high figures mentioned for cheese consumption have only been approached in Switzerland, Holland and France. The reason for the low consumption of cheese in Great Britain is doubtless due to the pronounced flavour of cheese. Modern dietaries have led to the development of an appreciation of delicate flavours, such as are obtained in fruits, meats and cereals. Nevertheless, it is to be hoped that with more scientific knowledge of what constitutes and produces a specific flavour or taste, it will be possible to market cheeses, the taste and flavour of which would be their own recommendation.

T.B. and Cheese.—All cheese is to-day manufactured by commercial firms; pasteurized milk is used; the risk, therefore, of infection by tubercle bacilli in cheese may be regarded as non-existent.

Eggs.—Eggs are very rich sources of certain body-building materials—protein, vitamins A and D and mineral salts. A hen's egg consists of 11 per cent shell, 59 per cent white, 30 per cent yolk. The edible portion contains 12·5 per cent protein, 11·5 per cent fat and 1 per cent carbohydrate. The white of the egg is essentially a solution of proteins (ovalbumin) and mineral salts. The yolk contains 16 per cent of proteins of which there are two, vitellin, a phosphoprotein resembling caseinogen of milk, and a globulin, livetin. The yolk is very rich in vitamins A and B_1 and also contains appreciable amounts of riboflavin and vitamin D, but does not contain vitamin C. A comparison of the nutrient values of 1 pint of milk, 1 oz. of cheese and 1 egg is given in Table 35. It shows how excellent are these foods.

TABLE 35

THE COMPOSITION OF THE HEN'S EGG

per 100 *grams*

Nutrient	Protein g.	Fat g.	Carbohydrate g.	Vit. A I.U.	Vit. B_1 μg.	Calcium mg.	Phosphorus mg.	Iron mg.	Calories
Egg, whole .	12·5	11·5	1·0	1000	150	60	180	3·0	160
,, yolk .	16·2	30·5	—	3000	150	131	495	6·13	350
,, white .	9·0	—	—	—	—	5	33	0·10	37
,, dried .	45·8	42·0	3·2	3000	400	219	—	11·5	574

Nutrient	Protein g.	Fat g.	Carbohydrate g.	Vit. A I.U.	Vit. B_1 μg.	Calcium mg.	Phosphorus mg.	Iron mg.	Calories
One pint of fresh milk contains	19·0	21·0	26·0	800	260	684	541	—	380
One egg, weight 50 g., contains	6·2	5·4	—	500	75	30	90	1·5	75
Cheese, 1 oz. (Cheddar) contains . .	7·1	9·8	—	370	10	231	156	0·2	121

Previous to the war egg consumption in the United Kingdom was 3·4 eggs per head per week; of this number 1·8 were home produced. Of imported eggs practically 90 per cent came from non-Empire countries—Denmark, Holland, Belgium and

Poland. The reorganization of poultry farming should in time restore these European sources of supply. New advances in the methods for the dehydration of foods, supervised by the Food Investigation Board of the Department of Scientific and Industrial Research, should open up a wider market in this country for eggs from China. In the year 1937–38 Great Britain imported from China in liquid form, the equivalent of 1000 million eggs in shell. The possibility of transporting eggs in the dry form will give a tremendous impetus to this section of the trade in eggs. The war-time scarcity of eggs has impressed upon most the part which they should play in all dietaries. It is not too much to state that a consumption rate of 1 egg per day per head of the population should be accepted as our standard.

Meat.—The term meat includes the flesh of mammals, poultry and fish, for these are almost identical as far as nutrition is concerned. The important point with regard to meat is that it contains proteins of high biological value. Approximately, lean meat is made up of protein 20 per cent ; water 75 per cent ; with a varying amount of fat within its texture. There are practically no carbohydrates in meat ; but protein will give rise to sugar, 58 per cent of its carbon being converted into glucose in the body. Beef, veal, lamb and pork contain from 18 to 22 per cent of protein, while the fresh organs, liver, kidney, tongue and sweetbreads have 17 to 19 per cent. The nutritive value of meat is enhanced by the presence of fat, not that which is seen in layers on top of the meat or under the skin of the animal, but that within the tissue. It is the fat which improves the flavour but slows digestion. Mineral salts and extractives add to the appetizing taste and to the flavour of meat. Extractives are readily soluble in water and upon them depends the tastefulness of the soups made from meat. They stimulate appetite and digestion and therefore to begin a meal with soup is a very sound physiological procedure. Extractives of meat are of importance because they are of two kinds ; those which give rise to uric acid in the body and those which do not. Uric acid is not entirely a waste product, a certain amount is excreted by the kidneys, but some is reabsorbed by them in order to keep the uric acid content of the blood at its physiological level. When there is an excess of uric acid in the blood stream, there may be some delay in reducing it to the normal

level and in some cases it may never be so reduced. Uric acid is the end-product of the breakdown of the nucleo-proteins, which are complex combinations of proteins with nucleic acid and are found in the body as well as in the meat ingested. It should be noted that red muscle does not necessarily contain more uric acid-forming substances than white. Meats are acid forming, not because of the presence in them of uric acid or uric acid-forming substances, but because they contain comparatively large amounts of the minerals, phosphorus and sulphur. In meat, the balance between acid-forming and base-forming elements is in favour of the acid, and where there is a preponderance of phosphorus and sulphur over sodium, potassium and calcium, then the blood becomes less alkaline and the urine more acid than normal, a change which favours the deposition of salts in various tissues.

Meat is a good source of iron, but in this respect it is by no means so valuable as liver, kidney and egg-yolk. And also with regard to its proteins of high biological value, these are no more valuable than those of milk and eggs. The organs, liver, heart, kidneys, thymus, pancreas, are richer in iron than is muscle, but they are also richer in acid-forming substances. Beef, poultry and fish are good sources of phosphorus, fish and poultry being superior to beef. Of the fish, herring, salmon and mackerel are the best, in the order named. Chicken has a phosphorus content comparable to that of mackerel. The whole egg comes in the same category, but egg-yolk is greatly superior to all of them in its phosphorus content. Brief though this survey of protein foods has been, it shows how abundantly nature has supplied us with the essentials for the growth and repair of the body. It is not our right to condemn any one of the protein-rich foods, but our privilege to select with discretion and to use in moderation those foodstuffs we deem most suitable for ourselves.

The Advantages and Disadvantages of Meat in the Diet.—The advantages are that good meat is easily cooked, it stimulates appetite, is well digested and is a fuel substance which contains complete proteins. Its disadvantages are: it contains more uric acid-forming substances than most foods, a disadvantage which it shares with eggs, it is poor in calcium and vitamins and is generally more expensive than most of the rich protein foods. Of the flesh foods, fish is generally, in

coastal areas, the cheapest ; while it has less iron and extractives than meat, and is therefore to some never so tasty as meat, it has a high content of phosphorus, and certain fish, such as herring, are rich in vitamins A and D.

While meat certainly has appetizing properties which make it an attractive and valuable addition to one's dietary, it contains nothing which would make it an indispensable foodstuff. The gloomy picture often drawn of those who suffer from arthritis, chronic rheumatism, kidney pains, intestinal toxins, and headaches and fatigue as a result of eating uric acid-producing meat is one with which we are all familiar. It is, however, not a reflection on meat but on the lack of sense not unusually found in the children of men. The picture is true, but it is by no means produced only by excessive meat ingestion ; the overeating of any rich protein food will produce similar effects. None of these effects need be produced in a normally energetic individual who eats rich protein foods in moderation, includes liberal amounts of milk, fruits and vegetables in his diet, drinks plenty of water and prevents protein putrefaction by a normal consumption of sugar.

If one examines the pre-war statistics of food consumption of the people of Great Britain and the United States of America, one will see certain contrasts and parallels. From the Imperial Economic Committee's Reports on Meat and Dairy Produce, 1937–38, it can be seen that the average weekly consumption of meat, including veal, mutton, lamb, bacon and ham, was 41 oz. per head of the population. The total meat consumption per head per week for the U.S.A. was 42 oz. ; Canada 44 oz. ; Australia 61 oz. and New Zealand 70 oz. Neither poultry, which constitutes but a small percentage (about 4) of the total meat consumption in the United Kingdom, nor fish is included in these figures. Of these animal products about 50 per cent is home produced. Since during the war we have been able to secure only about 12 to 16 oz. per week of meat, an amount universally regarded as inadequate to satisfy the adult palate, and in view of continuing restrictions on meat consumption, it is well to state what should be, or may be accepted as, an adequate weekly intake of meat. The League of Nations standard of 1935 was 23 oz. of meat, including fish ; the Stiebling standard in America was dual, an adequate one of 28 oz. and a liberal one of $44\frac{1}{2}$ oz., made up chiefly of beef, veal and pigmeat. In

the U.S.A. and Canada the consumption of mutton and lamb was 2 oz. per head per week in contrast to 8·7 oz. per head per week in this country. The days of pre-war dietetic liberality having passed and the country having experienced a period of severe restriction of animal proteins, it may be asked, " What should the optimum meat intake be ? " Dr. Wright, of the Hannah Research Institute, Ayr, gives it as his opinion, that the total meat consumption should be " 30 oz. per head per week ". " The subdivision of meat between beef, mutton and pigmeat should, however, follow British rather than American food habits, which would place the dietary requirements at roughly 14 oz. of beef, 7 oz. of mutton and 9 oz. of pigmeat per head per week." Of this last amount it is suggested " that two-thirds should be available as bacon and ham and one-third as pork ". It will be noted, with some appreciation of the fact, that fish, offal and poultry are excluded from these figures.

Differences in dietary habit, in so far as the animal protein foods are concerned, depend on several factors. That mutton and lamb as well as beef and veal should bulk largely in New Zealand and Australian consumption to the exclusion, almost, of pigmeat, and that on the American continent, mutton and lamb should suffer even a greater exclusion in favour of beef, veal and pigmeat, must be attributed to ecological and economic factors. In Great Britain in 1938 the consumption distribution was more even, being, for beef and veal 19·3 oz., mutton and lamb 8·7 oz., pigmeat 13·1 oz., or 48, 22 and 30 per cent respectively. If Dr. Wright's suggested amounts of 14, 7 and 9 oz. for beef, mutton and pigmeat, respectively, be accepted, there would, and rightly, be no alteration of the percentage allocations of these foods which would be 47, 23 and 30.

As to post-war trends in the importation of bacon, it would be unwise at present to hazard a guess. In the first world war, Danish supplies were cut off and by 1918 the United Kingdom was importing from U.S.A. not the 1913 Danish quota of 130,000 tons but 500,000 tons of bacon. Previous to the present war 20 per cent of our bacon was imported from North America, 56 per cent from the Continent. Between 1938 and 1944 the average consumption of pigmeat fell from 8·4 oz. to approximately 5·8 oz. per head per week, and this consumption figure was only made possible by a great increase in exportation of bacon from Canada and the U.S.A.

Fish.—The average composition of the edible part of non-fatty or white fish is, water 80 per cent, protein 16 per cent and fat 0·5 to 0·4 per cent : in the fatty fish the difference in composition is due to the high fat content, namely 10 to 15 per cent ; protein is changed but little, while the water is reduced to, 66 to 70 per cent. The value of fatty fish in respect of vitamins A and D has been referred to in the chapter on vitamins.

The dietary significance of fish is first as a source of protein, second as a source of the fat soluble vitamins. Demersal fish, i.e. fish living at the bottom of the sea, are chiefly non-fatty ; examples are cod, ling and haddock which have about 0·5 per cent, plaice 2 per cent and halibut 5 per cent of body fat. The pelagic or surface fish are generally fatty fish, e.g. herrings with 18 per cent, salmon 15 per cent, sprats 13 per cent, sea trout 10 per cent and mackerel 8 per cent of body fat. In 1938 herring formed about 94 per cent of all landings of pelagic fish. They show wide seasonal variations in their fat content which is high between January and August and low between September and December. The total landings of fish, demersal and pelagic, contribute in approximate figures 35 grams of protein and 20 grams of fat per head per week to British dietaries (Lovern, 1944).

Herring flesh contains varying amounts of vitamin D, the average being about 850 I.U. per 100 grams. The liver oil of the herring is very rich. It is, however, from the livers of cod that the commercial cod-liver oil is prepared and this contains 100,000 I.U. of vitamin A and 20,000 I.U. of vitamin D per 100 grams (Ministry of Food, 1945). Halibut liver oil, of which relatively small quantities are manufactured, is extraordinarily rich in vitamins A and D, being 100 and 10 times greater for vitamins A and D respectively than for these vitamins in cod-liver oil. Investigations into the whole problem of the potential contribution of fish to the British diet have been assiduously pursued for many years at Government Fishery Research Stations. The importance of this work on the future of the fishing industry and its significance in relation to national health cannot be correctly assessed until all the work has been published. Enough is known of the progress of these researches to say that if scientific advice is accepted and energetically acted upon, the harvest of the sea will not necessarily be greatly increased, for there is a limit to which any area of the sea can be

fished without suffering depletion of its stocks, but it will certainly be made more available to all and that independently of periods of seasonal abundance and scarcity.

Butter.—No consideration of the protein-rich foods can be regarded as complete without some reference to this important product of milk. The scale of home production of cheese and butter is determined by the success with which the demand of the consumer for liquid milk is met. As long, as at present, the demand outruns the supply of liquid milk, cheese and butter will continue to be heavily imported foodstuffs. And since it requires $2\frac{1}{2}$ to 3 gallons of milk to produce 1 lb. of butter, butter making should never, in this country, take precedence to the production of fresh liquid milk. Pre-war figures show that of a total consumption of 7·5 oz. of butter per head per week, 6·9 oz., or 92 per cent, was imported (1937–1938). Of imported butter 50 per cent came from Empire countries, chiefly New Zealand and Australia, the remainder from the Low Countries and the Irish Free State. Butter is made by separating milk and cooling the cream which is then graded into sweet and sour. If a ripened cream butter is to be made, a pure culture of the *streptococcus lactis* is added to start the souring processes. The best sweet butter is made directly from unripened or sweet cream. The nutritive value of butter lies in its high content of fat and vitamins A and D.

TABLE 36

COMPOSITION OF BUTTER (EMPIRE IMPORTED) AND MARGARINE

per 100 *grams*

	Water per cent	Protein g.	Fat g.	Calories	Vit. A I.U.	Vit. D I.U.
Butter .	15	0·5	82·5	745	4000	60
Margarine . (vitaminized)	14	—	85·3	768	2000	200
Dripping .	1	—	99·0	891	100	30

Butter is not a pure fat in that it contains small amounts of caseinogen and lactose. Most of the water, the protein, lactose and salts are found in the fluid left after the cream or fat has been removed. This fluid—butter milk—corresponds in

composition to the milk from which the cream has been taken and is very nutritious.

During the war vitaminized margarine has introduced itself most effectively into British homes. A ration of 2 oz. of butter over a period of 5 years reflected a fall of 70 per cent in butter consumption which was well balanced by a 90 per cent increase in margarine consumption. It is difficult to say to what extent the process will be reversed in the post-war period when the butter ration is increased. It is accordingly only in terms of an approximation that suggestions can be made with regard to post-war standards of butter consumption. The League of Nations (1935) standard was 18 oz. per head per week; the Stiebeling standard, 12·5 oz. per head per week. To pass from 2 oz. of butter per head per week to 1 oz. per head per day would to many be a most desirable change. The steady improvement in the methods of production of margarine with its standardized content of vitamins A and D has led to a greatly increased consumption of an economical substitute for butter. Margarine is, however, not a perfect substitute for butter. It is formed by the hydrogenation of unsaturated fats, usually vegetable oils: it does not contain the lower fatty acids of butter, which accounts possibly for the difference in flavour. In the interests of nutrition, particularly of children and adolescents, it would be well to stress the value of butter as the desirable natural product. It is known that the food upon which cows are fed determines the quality of the milk and therefore of the butter made from it. Cows fed on excellent pasture in sunny climes produce milk of the highest nutritive value, therefore, butter made from the milk of New Zealand cows is to be favoured. If the greater consumption of margarine in respect to butter were to continue, it is conceivable that more New Zealand and Australian milk would be diverted to the making of cheese. This would be advantageous in helping to raise our consumption of cheese. More milk might also be utilized for the greater production of condensed and dried milks. The diversion from butter to other milk products would result in an all round gain in nutrients.

Time alone will tell what the new standards in protein-rich foods will be. But, standards apart, it would appear that milk production should have first priority followed by poultry farming and meat production. The great demand for liquid

milk, its high nutritive value and the greater efficiency of milk production compared with meat production would support this. Milk and meat production are further bound up with the problems of the supply of cereals and concentrates for the feeding of cattle. To the farmer, the nutritionist and the economist the production of protein-rich foods is an eternal balancing of possibilities and probabilities.

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CHAPTER XIV

VEGETARIANISM

THE word vegetarianism is just about one hundred years old; descriptive of a mode or habit of living, as regards food, it is as old as the ancient faiths of the Orient.

Vegetarianism generally refers to a diet from which fish, flesh and fowl have been excluded; more particularly, it demands the further exclusion of milk, eggs and cheese. The prohibition of fish, flesh, fowl, milk, eggs and cheese from the diet leaves but little choice of foodstuffs from which to satisfy the physiological requirements of an active adult. That the requirements could be satisfied by the use of grains, vegetables, fruits, nuts, honey, sugar and treacle some will deny. The suitability, for the human digestive tract, of a diet consisting of these foodstuffs is certainly open to question. There are but few races and religious sects who live upon such a strict diet; high caste and strictly orthodox Hindus and Trappist Monks are amongst them.

One has heard in the past, and will doubtless hear in the future, a great deal about the virtues of vegetarianism. Numerous publications appear in which animal protein is condemned out of hand, carbohydrates are viewed with suspicion and only the vegetables and coarse grains are regarded with unqualified approval. While making use of scientific knowledge, many writers on vegetarianism omit all reference to the scientific origin of the facts they proclaim, and not a few avail themselves of every opportunity to hold up to contempt the findings of medical scientific investigators. Many of these publications are characteristic of the food faddist, of the person whose main interest is not national or individual health but merely finance. If anyone has anything which he or she considers of value to the health or well-being of the community he or she should make it unconditionally known. Many people are far too ready to believe all they read. They forget that there is nothing so dangerous, so misleading as a half-truth. One should therefore emphasize the importance of exercising a critical judgment, remembering that all knowledge is not to be found under any

one cap, neither is infallibility the prerogative of any one individual. Realizing these facts one will not be led away by any suggestions that all the ills that flesh is heir to can be cured by any specific diet. True vegetarianism demands that nothing that is of animal origin be eaten; only that which is derived from plant life must be regarded as fit for human consumption. This rules out milk, butter and eggs, and creates the chief difficulty associated with the vegetarian diet, namely to secure an adequate amount of calcium and iron, the fat soluble vitamins and the complete proteins. The difficulty is immediately overcome by the inclusion within the diet of milk, cheese or eggs. But strictly, anyone who adds but one of these animal foods to the diet is not a vegetarian.

With regard to the proteins, the vegetables richest in these are the legumes, i.e. peas, beans and lentils. Dried beans and peas contain about 20 per cent, dried lentils 25 per cent of protein. In this respect they compare favourably with meats in general, but many of their proteins are incomplete, they are not of such high quality nor are they so easily digested as the animal proteins. The other vegetables, leafy, fruit and flower vegetables, and the tubers are of no value as sources of protein. When we look to the vegetables as sources of energy we find two classes that are of distinct value, they are the seed vegetables or legumes and certain of the tubers, for example potatoes, carrots and turnips. These are often referred to as the starchy vegetables and they are very good fuel foods. Reference has already been made to the mineral salt content of the various vegetables and it was shown that the legumes which are such good sources of protein are also good for supplying calcium, phosphorus and iron. To secure the best possible supply of mineral salts from vegetables one should select peas (dried or fresh), beans, lentils, cauliflower and kale.

With regard to the vitamins in our menus, the vegetables play a very important part. It will be remembered that the fat soluble vitamins, A and D, are found in animal tissues and animal products, i.e. liver, milk, butter and eggs. Apart from these we have to rely upon vegetables for the supply of our vitamins. There are very few vegetables which do not contain two out of the three vitamins, A, B and C, but the amounts of the vitamins in our vegetables vary considerably. Reference to Table 37 will show the value of the vegetables in

comparison with other foods. The leafy vegetables are excellent sources of vitamin C ; the fruit vegetables, i.e. tomato, cucumber, vegetable marrow, pumpkin and melon, with the exception of the tomato, are not. Practically all vegetables are well stored with vitamin B_1. Carrots, watercress, kale, parsley, spinach, lettuce and turnip tops are the only vegetables richly supplied with vitamin A or carotene. A close study of the Table showing the protein, carbohydrate, mineral and vitamin content, and the calorific values of certain vegetables will be well repaid. It is by such a study that we are enabled to make suitable selections and to take as full advantage as is possible of the wide range of foodstuffs at our disposal. It is indeed surprising that the great variety of vegetable products has not led to a fuller and better use of vegetables in the dietary régime of the people of this country. It is true that vegetables form a rather unconcentrated food and that it is difficult for man to eat a large enough bulk of them to secure his need for proteins, mineral salts and vitamins. It is none the less true that the stomach and intestine of man are not adapted to receive and to digest such bulky and unmixed diets as are advocated by the strict vegetarians. It is also well established that we must secure our first-class proteins from sources other than vegetable, and the best sources for these are milk, eggs and meat. To expect, in this country with its less than temperate climate, its lack of sunshine and its expensive foodstuffs, to secure a sufficient supply of first-class proteins wholly from vegetables is expecting too much and, if persisted in, will merely deprive the body, both of the growing child and the adult, of the best and most easily assimilated amino-acids, which are to be found in proteins of the highest biological value. This in no way condemns the use of, nor detracts from, the value of fruits and vegetables as articles of diet. There is no reason why we should not learn from Canada and the United States of America how to put new life into our menus by the wise use of fruits and vegetables. We have in this country still to learn how to eat our vegetables raw : it is merely a matter of presentation. Is it a question of national prejudice or perhaps national honour, that we hold, particularly in the North, the leafy vegetables in such high disregard ? Must we preserve the tradition of our fathers ? It has been said " the Englishman's menu consists of, first, boiled potatoes, second, boiled cabbage, and third, boiled

cabbage ". It is sometimes even worse than that, for the water in which the cabbage has been boiled and which contains 30 to 50 per cent of the salts of value to the body, is still, too often, thrown away. In many cases it would be better if one threw away the so intensely boiled cabbage and drank the bree. The greater use of vegetables is therefore a matter of education, not of money. The task before us then is to get people to understand that it is not money but common sense that is required in arriving at a sound physiological balance between meat and vegetables. If people in this country had the initiative in food supply which characterizes the Canadian and American people there would be an all the year round supply of good vegetables and ice cream, both valuable adjuncts of any diet. From vegetables to ice cream may seem a long jump, but it is so only to those who do not know how to eat the one or enjoy the other. We shall never be able to give our children good cheap ice cream 365 days in the year until we have learned the art of central heating. To heat uniformly our rooms and public buildings to 65° or 68° F. will not destroy the stamina of our people, far otherwise ; it will materially aid the improvement of our physique, for it will add to the comfort of living by dispelling the chill and dampness which are such fruitful causes of respiratory, circulatory and rheumatic disease in this country.

Fruits.—It is not unusual in discussing the comparative values of foods to include fruits with vegetables. This is misleading because fruits, with the exception of dried fruits, such as apricots, dates and figs, have not supplies of minerals and vitamins comparable to those of the vegetables (Table 37). Blackberries, black currants, oranges, strawberries, rhubarb and raspberries are the only fruits which contain substantial amounts of calcium. Since most fruits are eaten raw, they are amongst the best sources of vitamin C. With the exception of apricots, greengages, peaches, plums, prunes and tomatoes, fruits are not good sources of vitamin A. Together, fruits and vegetables play a very important part in the preparation of menus just as by their variety they stimulate appetite and digestion. Both, because of their base-forming properties, help to maintain the acid-base balance of the blood in favour of the bases, which is the normal condition of the body fluids. Having little protein and fat, both add to the carbohydrate intake and thus combat

intestinal putrefaction, which is rather encouraged by a too free ingestion of meat, bread and fats. As is well known, intestinal activity is greatly helped by fruits and vegetables. This is due to the presence of acids, salts and cellulose. In case anyone should be unduly impressed by the emphasis laid on roughage by certain popular writers on that world-wide evil, constipation, let it be said that recent calculations on the amount of residue left by fruits and vegetables go to show that it is by no means so great as has been estimated, or perhaps better, assumed. Green leaves of cabbage, lettuce, etc., are found to leave a residue which is not more than 3 to 5 per cent of their original weight.

Nuts.—Nuts are valuable sources of protein, fat and mineral salts, but they must be well masticated. Their protein is of high biological value. Because of their fat content, they retard digestion. Almonds, peanuts and walnuts contain vitamin B_1: in no others are vitamins found and in all carbohydrate is low. It should, however, be noted that as eaten generally, nuts are not to be regarded as rich sources of minerals.

From what has been said it will be readily understood that, apart from the stricter castes of the Hindu faith, the strict vegetarian does not exist. If by vegetarianism one means the greater use of fruits and vegetables in a well-balanced diet of milk, eggs and cheese, then most of us would agree as to the excellence of such a dietary régime. But whatever we eat we have no right to conclude that what is excellent and health-promoting for one is necessarily essential for the well-being of others. There is no single indispensable article of diet, be it meat, cabbage or nuts. When we have all the essentials for body building and the maintenance of health in milk, eggs, whole grains, meat, vegetables and fruit, what reasonable grounds can there be for selecting one to the exclusion of the others? To those who have studied the nutritional needs of the body as a whole and the various means of satisfying them, the stupidity of going to dietary extremes must be apparent. Every foodstuff has its rightful place. One must not be misled into interpreting the value of vegetables and fruits only in terms of a favourable percentage content of any one or more nutrients. By no objective standard can the importance, in nutrition, of flavour and lusciousness be assessed or the part played by nutrients in stimulating digestion be determined. Why con-

demn refined sugars or rice because they do not contain mineral salts? They are the finest and cheapest fuel supplies we have. One might just as well condemn certain vegetables because they do not contain carbohydrate and first-class proteins. If we are to be consistent in our criticisms we should heartily condemn the habit of drinking water because it contains neither proteins, carbohydrates, fats nor vitamins.

Some False Ideas Concerning Foods.—In the realm of food no less than in other spheres, do we find superstition, ignorance, credulity and a lack of a critical spirit, all of which are responsible for the quaint and often absurd statements which one hears concerning foods. There are many who, with a persistence worthy of better things, make experiments, almost daily, with their digestive functions, and arrive at conclusions not only as to what is good or bad for them but for others. It is curious, or perhaps it is not so curious, that people with the least experience are the most prone to dogmatize. Having discovered a certain relation between themselves and some foodstuff, they refuse to keep an open mind and immediately proceed to make pretentious claims for, or dogmatic statements against, a certain type of food. Many, finding that not a few people agree with them, proceed further to publish the so-called facts, to claim infallibility for themselves and to abuse or disagree with all who will not conform to their manner of thought and action. The great art of advertisement had, previous to the war, deluged the world with the most wonderful array of fanciful facts, based upon evidence of the most ephemeral and imaginative kind concerning the whole function of man as a physiological, sociological and artistic individual. It is a type of propaganda which in the post-war period should either be abolished or rigorously controlled. It is not suggested that there is not a very legitimate use for intensive advertising; one need only look at certain published advertisements by iron, coal, steel and engineering firms to realize that they are the outcome of scientific acumen and research and lead, not only to higher standards of quality in goods produced, but to improved standards of living. What is suggested is that in certain spheres there has been a decided abuse of the art of advertising. With a little common sense, a small modicum of knowledge of the needs and activities of the human body, many of these rather stupid advertisements could have been made to benefit

in a very real sense the people who do want help and the businesses which do want money. When one read the numerous pre-war publications on health, one met truth, half-truth and a general sprinkling of humbug and nonsense. Surely in the new age, the age of the use of atomic energy, something more in accordance with advancing knowledge will be forthcoming.

Amongst many false suggestions, we find the statement abroad that starches should not be eaten with protein, because protein stimulates the secretion of acid in the stomach which it is affirmed stops the digestion of starch. This is altogether unnecessary advice. The acid of the stomach only stops the enzymatic breakdown of starch which is started in the mouth by the salivary enzyme ptyalin. To stop enzymatic digestion of starch in the stomach is merely to prepare the way for its further digestion in the intestine by means of the starch splitting enzyme, amylase. There is no incompatibility between any two starches and the delay in starch digestion in the stomach is quite physiological. To those who wish to reduce their weight, the idea of not mixing starches and proteins is of value, if, when one eats only a protein or starchy meal, one does not increase the usual intake of protein or starches. Unmixed with a liberal amount of sugar or starchy food, the protein of the meal will be more quickly digested by the pepsin and hydrochloric acid in the stomach. There is one fallacy in this connection which must be removed and that is, to digest starches the stomach juices should be alkaline. If the stomach were the only place for the complete digestion of starches, then its secretion would have to be neither acid nor alkaline, but neutral (pH 6·9–7·0). The salivary digestion of starch by means of ptyalin is carried on in the stomach until the hydrochloric acid, penetrating the salivary mass, destroys the enzyme. Ere this destructive action is complete, usually in half an hour, 80 per cent of the starch has been converted to maltose. Alkalinity of the gastric secretion is not necessary for no further digestion of the maltose can take place until it reaches the first part of the intestine where the enzyme, maltase, awaits to convert maltose into glucose. In the intestine the pancreatic secretion presents these enzymes lactase, sucrase or invertase and maltase for the particular task of converting lactose (milk sugar), sucrose (cane sugar) and maltose (end-product of starch) into glucose, the only form in which carbohydrate is absorbed into the blood stream.

There are numerous myths concerning food. To take but three. We all have heard that "fish makes brains" because of the presence of phosphorus in it. Fish muscle has phosphorus, but more than phosphorus is required for building up brain tissue, and phosphorus is just as well supplied by eggs, milk, cheese, meat and whole grains. Another fallacy is that meat is necessary to build muscle. There is no such thing as special foods for building special tissues. That meat is responsible for the production of physical and mental energy is true; we need only look at the robust physique of certain carnivorous people and consider its action on dogs, but that meat is the one and only source of mental and physical energy is quite nonsensical. That it produces toxins as a result of protein putrefactive processes is another tale. All proteins, be they in cheese, milk, eggs or meat, if given suitable conditions, will break down and produce toxins. People who suffer from protein putrefaction in the alimentary tract are usually examples of immoderation in eating protein-rich foods. The results of careless dieting, e.g. unhygienic bowel conditions, should not be attributed to meat or eggs, but to those who have not that modicum of wisdom necessary for the simplest regulation of their own lives.

The old controversy of white versus whole wheat bread has been overdone. Whole wheat contains decidedly more of the mineral salts and vitamins, particularly vitamin B_1, than does the highly-milled article, but whole wheat or wholemeal bread cannot supply all our minerals. Even given a suitable quantity of wholemeal bread or wholemeal in the diet, and its use is decidedly to be encouraged, it will be necessary to take other foods to bring the mineral salts and vitamins up to the optimum needs of the body. And to that end we take milk, eggs, cheese, vegetables, liver (for iron) and sea foods. If people can be encouraged to take wholemeal products so much the better, but it is quite wrong to over-emphasize the importance of one article of diet. Generally we find that such emphasis is followed by a moral, namely advice to take a certain brand of meal or some synthetic product containing more base-forming salts than the kidney can well excrete. Over-indulgence in mineral salts gives more work for the kidneys, leads to a turbid urine and to the possibility of calculi or stone formation in the kidneys or bladder. If diets are deficient in calcium, phosphorus and

iron then such deficiencies can readily be made good, but one must first know the specific deficiency and the requirements

TABLE 37

TABLE SHOWING THE COMPARATIVE VALUE OF CERTAIN VEGETABLES, FRUITS AND NUTS

All Amounts are per 100 grams (Edible Portion)

VEGETABLES

	Protein g.	Carbo-hydrate g.	Calories	Calcium mg.	Phosphorus mg.	Iron mg.	Vit. A I.U.	Vit. B_1 μg.	Vit. C mg.	Wastage per cent
Leafy Vegetables—										
Brussels sprouts	4·4	4·0	34	27	134	1·2	400	120	100	25
Cabbage .	1·5	5·0	26	65	28	1·0	900	75	70	30
Kale . .	3·9	4·5	34	200	67	2·5	8,000	120	130	30
Lettuce .	1·1	1·6	11	26	42	0·7	4,000	75	15	20
Parsley .	5·2	—	21	325	—	8·0	13,000	120	150	0
Spinach .	2·7	2·5	21	—	—	—	13,000	100	65	25
Turnip tops .	2·5	3·5	24	—	—	—	10,000	120	100	25
Seed Vegetables—										
Beans, broad	7 2	9 5	71	30	300	1·1	—	—	30	75
,, French	1·1	2·6	15	33	—	0·7	600	75	10	5
,, runner	1·1	2·6	15	33	—	0·7	600	75	20	25
Lentils .	23·8	47·9	287	39	424	7·6	50	450	0	0
Peas (split) .	22·1	50.9	292	33	813	5·4	200	450	0	0
Soya bean .	40 4	13·3	426	218	420	6·9	0	660	0	0
Tubers and roots—										
Carrots .	0·7	4·9	22	48	45	0·6	10,000	60	10	5
Onions (bulb)	0·9	4·7	22	31	46	0·3	0	30	10	5
Parsnips .	1·7	10·2	48	55	75	0·6	200	120	10	35
Potatoes .	2·0	16·2	73	8	56	0·7	0	120	30	25
Turnips .	0·8	3·4	17	59	46	0·4	0	35	25	35
Fruit Vegetables—										
Cucumber .	0·6	1·6	9	23	31	0·3	0	45	10	25
Tomatoes .	0·9	2·5	14	13	25	0·4	3,000	60	25	15
Flower Vegetables—										
Asparagus .	2.0	2·4	18	28	39	0·9	700	180	60	80
Cauliflower .	2·4	3	22	—	60	0·9	0	100	70	30
Celery . .	0·9	1·2	8	52	35	0·6	0	30	5	25
Watercress .	2·9	0·6	14	222	—	1·6	5,000	120	60	15

Note.—The sole source of vitamin A potency in vegetables and fruits is carotene.

Fruits

	Protein g.	Carbo-hydrate g.	Calories	Calcium mg.	Phosphorus mg.	Iron mg.	Vit. A I.U.	Vit. B_1 $\mu g.$	Vit. C mg.	Wastage per cent
Apples (eating)	0·3	10·5	43	4	6·8	0·3	40	45	5	20
Apricots .	0·6	6	26	17	21	0·4	750	30	10	8
Bananas .	1·1	17·3	74	7	28	0·4	80	50	10	40
Blackberries	1·3	5·8	28	63	24	0·9	300	20	20	0
Currants, black	0·9	5·9	27	60	43	1·3	90	45	200	0
,, red	1·1	4·0	20	36	30	1·2	25	45	45	0
Grapefruit .	0·6	4·8	22	17	15	0·3	20	70	40	50
Greengages .	0·8	10·6	46	17	22	0·4	400	45	5	6
Oranges . .	0·8	7·7	34	41	24	0·3	300	75	55	25
Peaches . .	0·6	8·2	35	5	18	0·4	750	20	10	13
Pears (eating)	0·2	9·4	38	7	9	0·2	10	20	3	25
Pineapples .	0·5	10·4	44	12	7	0·4	100	75	20	50
Plums (Victoria)	0·6	8·6	37	11	16	0·4	400	45	3	6
Raspberries .	0·9	5·0	24	41	28	1·2	70	20	30	0
Rhubarb .	0·6	0·9	6	103	21	0·4	—	20	10	25
Strawberries .	0·6	5·6	25	22	23	0·7	15	20	60	3

Nuts

	Protein g.	Fat g.	Calories	Calcium mg.	Phosphorus mg.	Iron mg.	Vit. A I.U.	Vit. B_1 $\mu g.$	Vit. C mg.	Wastage per cent
Almonds .	20·5	53·5	579	247	442	4·2	0	240	0	65
Brazil nuts .	13·8	61·5	624	176	592	2·8	0	—	0	40
Cocoanuts .	—	36·0	352	13	94	2·1	0	—	0	30
Peanuts .	28·1	49·0	584	61	365	2·0	0	900	0	30
Walnuts .	12·5	51·5	532	61	510	2·4	0	300	0	40

and not rush after shrapnel-like remedies. Many people are receiving diets greatly deficient in mineral salts, but there are means at their disposal for making good the deficiencies, for example, by taking more of the simple foodstuffs which we know contain the elements, namely, milk, cheese, leafy vegetables and whole grains. There is no need to have recourse to highly-vaunted preparations, which are usually costly and often lead to an imbalance of nutrients in the diet.

And what of the natural or unnatural cravings for sugar, cakes, tobacco, alcohol, tea and coffee ? Were we to look more

carefully into our consumption of these we might find the means very close at hand for the improvement of our individual as well as our national health.

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CHAPTER XV

DIETARY STANDARDS AND DIETARY PLANNING

THE evolution of dietary standards may be said to have begun in the early days of magic and medicine when disease was prevented or cured by the prescribing of specific foods. The earliest example is possibly the cure of night blindness by the use of liver. The various reports on the treatment of scurvy in the seventeenth and eighteenth centuries are but landmarks in the history of dietary planning; not until the middle of the nineteenth century do we find dietary requirements stated in terms of nutrients. In 1870 Voit, in Munich, suggested that the correct daily allowance for a man performing moderate work was 118 grams of protein, 56 grams of fat and 500 grams of carbohydrate; this supplied almost 3000 calories. Atwater in U.S.A. (1903) considered these requirements to be too low and was the first to maintain that standards must vary with conditions of activity and environment. All these standards were based on analyses of diets habitually consumed by men under different conditions of work and therefore were without any scientific foundation as standards of requirement. Chittenden (U.S.A.), criticizing standards based on controlled food consumption, suggested that a true standard should be based upon a measurement of protein metabolism, and that the requirement for protein could only be determined by a knowledge of the amount of protein which would keep the body in nitrogenous equilibrium. This idea of an equilibrium or balance of intake and output was further applied to calcium. The new method of standardization of requirements had at least the merit of being related to the person and not to his dietary habits.

In 1919 the Royal Society Food (War) Committee in reporting on the food requirements of man, accepted the standards determined by Lusk of Cornell University, U.S.A.; these were based upon very accurate calorimetric studies of the energy output of individuals of varying age and weight under controlled experimental conditions. Following upon numerous

studies of energy expenditure and of mineral and vitamin requirements by Benedict (U.S.A.), Cathcart (Glasgow), Lusk, Du Bois (U.S.A.) and others, the British Medical Association's Committee on Nutrition (1933) published a report in which they discussed the energy requirements of man in relation to health, weight and working capacity. For the requirements of women and children they adopted Cathcart and Murray's (1931) scale. While at this time no quantitative estimate was made regarding minerals or vitamins, they did suggest that protein should provide 10 to 15 per cent of the total Calories. In the same year (1933) Stiebeling of the U.S. Department of Agriculture published standards for Calories, protein, minerals (Ca, P, Fe) and vitamins A and C, and further, the standards were related to food. The latest standard is that of the National Research Council, Washington, U.S.A. (May 1941). It is an extension of the Stiebeling standard to meet all data presented by more recent scientific work. The theoretical standard allowances to meet the nutrient requirements per head of the population are given in Table 38. Since the composition of foods and human nutritional requirements are imperfectly known, the dietary standards must perforce be equally imperfect. The principle underlying a standard of diet is to select figures for the various known nutrients which are reasonably above the amounts on which symptoms of dietary deficiency might develop in the human being. Were the actual human requirements for all nutrients known there would be no need to trouble about minimal or basic diets, for the known amounts, in suitable proportion for age, sex, activity and other as yet unknown factors in the normal human being, would be both the optimal and minimal requirements and anything less would constitute a deficiency. In calculating standard allowances it has been assumed that 40 per cent of men and 30 per cent of women between the ages of 20 and 65 years are "very active" and the rest "moderately active". The recommended daily allowances for specific nutrients, published by the National Research Council, known as "the N.R.C. standard, 1941", were designed as a guide to the planning of good dietaries sufficient to maintain optimal health. It was not intended that "the standard" should be used as an infallible and rigid guide. Much dietary survey work has shown quite clearly that excellent health can be maintained on diets

supplying fewer Calories, less protein and even fewer vitamins than the respective amounts enumerated in the N.R.C. dietary standard. Many surveys, to some of which reference has been made, have shown that for adults the amount of animal protein, vitamin A and vitamin C, is surprisingly low, and yet, clinically, no evidence of undernourishment has been forthcoming. In the past the results of dietary surveys have been interpreted from standards which were not based on the dietary require-

TABLE 38

REQUIREMENTS PER HEAD OF POPULATION: THEORETICAL ALLOWANCES

	Stiebeling, 1933, 1939	League of Nations, 1935, 1936, 1937	U. S. National Research Council Standard, 1941
Energy requirement; net calories	2810	2980	2775
Per cent of total calories from protein	9·7	(12)	9·5
Protein, g.	68	(89)	66
Calcium, g.	0·90	0·83 (1937)	0·91
Phosphorous, g.	1·23	—	—
Iron, mg.	13 to 14	—	12
Vitamin A, I.U.	5800	2000–4000 (1937) (or more)	4696
Vitamin B_1, I.U.	460	300 (1937)	516
Vitamin C, ascorbic acid, mg.	71	30 (1937)	71
Riboflavin, mg.	1·74	—	2·3
Nicotinic acid, mg.	—	—	15·5
Vitamin D, I.U.	—	—	approx. 210

ments of normally healthy members of the community examined. The formulation of dietary standards for age, sex, condition of life applicable to the group or community, like calibration curves, should precede all dietary surveys; only then can a diet be recorded as adequate or inadequate. The potentialities for misuse of the "dietary yardstick" are clearly set forth by the Committee of the Food and Nutrition Board of the National Research Council of the United States of America, which calls for a recognition of their limitations and a proper interpretation of their values. These values have been translated into terms of foods in numerous published tables (e.g. Tables 41, 42 and 43) which as dietary patterns are worthy of consideration by

nutritionists, dietitians and all interested in the planning of good diets.

DIETARY PLANNING

Numerous experiments in planning diets to meet the theoretical requirements of adults and children have been made, and the results of the analyses of these diets have shown that, with the exception of calories, most of the nutrients exceed the theoretical requirements, some of them by large amounts. A

TABLE 39

REQUIREMENTS FROM ANALYSIS OF PLANNED STANDARD DIETS DAILY ALLOWANCES PER HEAD OF THE POPULATION

	1933 British Medical Association	Stiebeling, 1933			League of Nations, 1935, 1936
		Adequate diet at Minimum cost	Adequate diet at Moderate cost	Liberal diet	
Energy: Atwater calories in edible portion	2760	2980	2985	2930	2980
Per cent of total calories from protein	12	12	11	12	12
Protein, g.	84	89	84	87	89
Carbohydrate, g.	408	397	370	310	384
Fat, g.	88	115	130	149	121
Calcium, g.	0·69	1·28	1·26	1·27	1·30
Phosphorous, g.	1·32	1·72	1·58	1·61	1·59
Iron, mg.	15	13	14	15	13
Vitamin A, I.U.	5346	7094	7969	9093	6656
Vitamin B_1, I.U.	406	—	—	—	580
Vitamin C, ascorbic acid, mg.	91	88·5	126	154·5	114

comparison of the results of dietary analyses in Tables 38 and 39 will show that in the planned diets, 12 per cent of the total energy is derived from protein, and the protein intake and the vitamin A are greater than the theoretical requirement (Table 39). Important in the planning of diets is the finding, that high calorie diets to be palatable, must have a high protein content, for example, diets giving 4500 Calories may have as much as 120 grams of protein. Recently planned dietaries for U.S. soldiers in training have shown similar figures which would

tend to support the as yet unexplained need for increased protein in high calorie diets. It further emerges that in assessing the suitability of diets certain requirements must be fulfilled :

TABLE 40

SPECIFIED CONSTITUENTS IN FOODS COMPARED WITH AVERAGE ALLOWANCES PER 100 CALORIES, CALCULATED FROM N.R.C. STANDARDS (I. LEITCH, 1942, *Nut. Abs. and Rev.*)

	Protein, per cent of Calories from	Calcium mg. per 100 Calories	Iron mg. per 100 Calories	Vitamin A I.U. per 100 Calories	Vitamin B_1 I.U. per 100 Calories	Vitamin C I.U. per 100 Calories
N.R.C. allowance .	9·5	33	0·43	169	19	2·6
Type of food—						
Cereals, wheat flour, 85 per cent extraction	13	8	0·7	—	30	—
wheat flour, 72 per cent extraction .	14	5	0·3	—	8	—
Milk, whole . .	21	188	0·2	180	23	2
Cheese, whole milk .	28	232	0·3	325	2	—
Potatoes . . .	10	15	0·7	—	45	10
Dried beans, peas .	26	26	2·0	—	51	—
Tomatoes, citrus fruits	8 to 13	50 to 112	1·2 to 1·7	250 to 4300	38 to 87	114 to 138
Leafy green and yellow vegetables—						
green . . .	13 to 35	100 to 480	2·0 to 14·0	670 to 20,700	40 to 280	167 to 310
carrots . . .	11	127	1·2	14,700	44	9
Fats, butter . .	—	—	—	535	—	—
,, lard . .	—	—	—	—	—	—
,, bacon . .	7	2	0·5	—	36	—
Sugars . . .	—	—	—	—	—	—
Lean meat, poultry, fish						
meat . . .	15	2	1·0	14	8	—
fat fish . . .	38	10	0·5	75	3	—
white fish . .	95	26	0·6	—	26	—
Eggs . . .	32	42	1·6	250	31	—

these are, that the calories from protein should form 10 to 12 per cent of the total calories available and that certain nutrients should bear a definite relation to the energy value of the diet. The factual basis of these statements appear in Table 40, where it is shown that the percentage energy derived from protein is,

for bread cereals about 13, milk 21, cheese 28, potatoes 10, dried beans and peas 26, tomatoes and citrus fruits 8 to 13, leafy green vegetables 13 to 35, bacon and meat 25, white fish 95, and eggs 32 (Leitch, 1944).

The wide range of possibilities in planning diets is sufficient to show how elastic dietary standards must be. Dietary standards as in Tables 38 and 39 are but suggested optima, the "Calorie criteria" of Table 40, but guides to good selection. In planning diets regard must be had to the nature of the foodstuffs which form the major part of the dietaries of the people or community concerned. The modern attitude to the whole question of dietary planning is well put by Dr. Leitch. "It is obvious that if the foods supplying the major part of the energy in a diet are of such a composition that they supply also the major part of the requirements for the separate food constituents, protein, minerals and vitamins, it will probably be safe to plan for calories in the belief that the rest will take care of itself. But if the staple energy supplying foods do not supply the necessary protein, vitamins and minerals in due proportion, then the rest of the diet must be planned to make up the deficit. An examination of the composition of common foods and of the proportion in which they occur in common diets shows that, in planning diets, attention must be given, in the first place, to providing calcium and vitamins A and C, since these do not occur in adequate amounts in the staple energy supplying foods. In the second place, in certain circumstances only, vitamin B_1, iron and protein also should receive special attention since they are present in adequate amounts in the staple foods *unless* these are highly processed cereals, or include too high a proportion of sugar and pure fats. These deductions are fully supported by the results of dietary surveys everywhere. The constituents most often and most gravely deficient are calcium and vitamins A and C. Unfortunately the amounts of sugar and of processed cereals used are so high in many areas, especially in the diets of the poor, that deficiency of vitamin B_1 also, in extreme or minor degrees, is thought to be common."

In the selection of foods it must also be remembered that foods vary in composition. Not only does the selection influence food values, but the soil in which the plants have been grown, the food with which the animals have been fed and the

degree of ripeness of fruits and vegetables all play a part in determining the ultimate nutritional value of foods. Examples of this are numerous. Carrots vary in colour because of their carotene content ; a pale carrot may contain 1000 I.U., a red carrot 5000 I.U. per oz. ; cheddar cheese, a hard cheese, has 17 micrograms of riboflavin, while a cream cheese may have

TABLE 41

WEEKLY FOOD REQUIREMENTS PER HEAD OF POPULATION : WEIGHTS AS PURCHASED

	Stiebeling, 1933			League of Nations, 1936
	Adequate diet at Minimum cost	Adequate diet at Moderate cost	Liberal diet	
Flour, cereals . . oz.	68·7	49·1	30·7	61·6
Milk, or its equivalent . pints	8·3	9·8	9·8	10·7
Potatoes, sweet potatoes oz.	50·6	50·6	47·6	67·8
Dried beans, peas, nuts . ,,	9·2	6·1	2·2	2·0
Tomatoes, citrus fruits . ,,	15·3	27·6	33·8	17·9
Leafy green and yellow vegetables . . . oz.	24·6	30·7	41·4	30·4
Dried fruits . . . . ,,	6·1	7·7	6·1	—
Other vegetables, fruits ,,	26·1	64·4	99·7	—
Fats (including butter, oils, bacon, salt pork) . oz.	15·0	16·0	16·0	16·1
Sugars . . . . ,,	10·7	18·4	18·4	26·0
Lean meat, poultry, fish ,,	18·4	30·7	50·6	25·0
Eggs . . . . No.	3·5	3·5	7·0	7·0

Liquid milk allowance 1 pint per head per day for all except pregnant and lactating women, children and adolescents.

Liquid milk equivalent of the cheese allowance is included in the total of 10·7 pints of the League of Nations recommendations.

only 3 micrograms per oz. Early potatoes may have 8 mg. of vitamin C per oz., late potatoes but 1 mg. of vitamin C per oz. Summer milk contains 800 I.U. of vitamin A per pint, winter milk but half that amount, and even more drastic seasonal changes are seen in the vitamin D content of the body and liver oil of the herring. The over-ripe banana and orange have a lower vitamin C content than that which obtains when the fruits approach maturity. Dried green peas have no vitamin C until they have been made to germinate. Soil, season, storage,

variety, maturity, resistance to plant disease all are of importance in determining food values. There is a great need for more information along these lines. The question as to whether the genes or chromosome numbers or both are factors in determining nutritional values, still remains to be answered.

Sir John Orr and others have suggested that in order to meet the nutritional needs of the people of the United Kingdom, the production of milk and the consumption of eggs should be doubled, the consumption of fruit trebled and new methods in the marketing of vegetables established. Statements such as these are well borne out by a comparison of the consumption of certain foods in the United Kingdom in 1938 with that suggested as necessary if an adequate diet is to be secured by all. The supporting evidence is in Tables 3A and 40.

DIETARY PLANNING AND FOOD COSTS

The amount of food that may be selected to meet the weekly food requirements at different costs are given in Table 40. Liberal diets differ from minimal ones in several respects, the most noteworthy of which is the increased amount, in liberal diets, of animal protein, meat, eggs, milk, vegetables and fruits.

One of the most important tasks for people of small or moderate incomes is to know how to meet their nutritional needs at as low a cost as possible. It requires knowledge to select the foods best suited for body-building and for the supply of energy. To buy expensively does not necessarily mean that one is buying the best in the physiological sense. This is indicated by the fact that many who eat well suffer from indigestion, overweight and under-nutrition. Simple wholesome foods can be secured for a moderate expenditure, but it is just as true that many of the best foods—good quality proteins in the form of eggs, and mineral and vitamin containing foods in the form of fruit—do require money. It is no easy thing to advise just what to buy on a limited income in order to enjoy that range of foodstuffs which will combine palatability with essentials. There is no great difference between satisfying hunger and building up a healthy body. The supply of food quantitatively and qualitatively adequate, cannot, in the interests of sound nutrition, be dissociated from such factors as housing, health and happiness. In discussing the cost of

foods we must always discuss it in relation to its food value; body-building values as well as fuel values must be considered.

To secure a diet consistent with health we must select foods to supply :—

(1) *Energy*—Sugar, butter and cooking fats, and cereals.
(2) *Protein for body-building*—Milk, cheese, eggs, meat, cereals and legumes.
(3) *Mineral salts*—Milk, cheese, fruits and vegetables.
(4) *Vitamins*—Vegetables, fruits, butter, milk and whole cereals.
(5) *Fibre*—Vegetables and fruit.

Some foods are most economical for meeting energy requirements, e.g. sugar; others, particularly those which supply animal proteins, are the most expensive; and of those which supply mineral salts, some are expensive and some are cheap. Summarizing the uses of the various foodstuffs and their approximate cost, we have :—

Sugars—These are cheap or moderate in price and furnish energy, but only energy, for they have no mineral salts, vitamins or protein.

Fats—They are moderate in price, are excellent sources of energy and vitamins, but are without protein or mineral salts.

Cereals—While generally cheap sources of fuel and protein, they are relatively deficient in most minerals and vitamins. The exception to this statement are the whole grains, which contain vitamin B_1, and the minerals—phosphorus, calcium and iron.

Milk and Cheese—These are moderate in price, are excellent sources of protein and energy, and are rich in minerals and vitamins.

Eggs—These are relatively expensive, depending upon the seasons. They are excellent sources of protein and energy and are rich in iron and in the vitamins A, B_1, riboflavin, and vitamins D and E.

Meats—These are more or less expensive sources of protein and fuel, but they are deficient in certain of the mineral salts and vitamins.

Vegetables—These are generally moderate in price. The green vegetables furnish little energy but have good supplies

of mineral salts. The starchy vegetables, while good sources of energy, are not good sources of mineral salts. Seed vegetables, i.e. beans, peas and lentils, are excellent for calcium, phosphorus and iron and also for proteins. All fresh vegetables contain vitamins A, B_1 and C.

Fruits—Fresh fruits are usually expensive seasonal sources of proteins and energy. They are, with the exception of currants, blackberries and oranges, not sources of the mineral salts. Some are, and some are not, rich in certain of the vitamins. Almost all are rich in fibre. Dried fruits, apples, apricots, dates, figs, raisins, prunes, are the most economical of the fruits and should be freely used.

In planning an adequate diet at minimum cost it would be necessary to use meat very sparingly, eggs only for cooking and butter and margarine for vitamin A and for flavouring. Fruit should, if possible, be included in the list but its price and availability will depend upon where one lives. For example, in London, which is a very large fruit centre, it is very cheap, while in the North, far from any such centre, it is by no means cheap. When it is possible to increase the amount of money to be spent on food, or in the post-war years, as foods become more available, it is wise to buy more milk, cheese, fruits and vegetables. The present consumption of meats, eggs and butter is far too low. Eggs and butter should be quickly restored to their pre-war values if the diet is to be regarded as adequate.

Milk, fruits and vegetables are base-forming foods and good sources of vitamins. Apples, bananas, oranges, raisins, legumes and potatoes are all good "alkalinizers" of the body, and stand in contrast to the acid-forming foods, such as meat, eggs, breads and cereals.

Milk gives a good return for the money spent upon it. It is always unwise to economize on milk. Especially is this so in a low price diet, for it plays a far more important rôle in such a diet than it does in a high cost one. Sugars should be kept at about 12 oz. per head per week, for, used in excess, they spoil the appetite and prevent the eating of those essential foods which are rich in protein, vitamins and mineral salts. If more food can be bought, cereals should be reduced, fruits and vegetables increased and also to a smaller extent meat and eggs. Sugars need not be increased as there will be sufficient

increase in the carbohydrate intake with the increased consumption of fruits. When increasing the animal protein intake, the advance should be from milk and cheese to eggs and finally to meat; that is roughly the increasing order in cost in relation to availability of the biologically valuable proteins. While all cereals are sources of proteins, they should not be entirely depended upon for protein. Milk is the best supplementary food, for it gives the best supply of those amino-acids in which cereals are somewhat deficient.

With regard to fruits, the price of which varies so greatly, it should be remembered that the dried fruits—raisins, dates, figs, prunes and apples,—all having a good mineral content, can perhaps be bought a little more economically than most fruits, and therefore should be used as much as possible in a moderate or minimum cost diet. Of the fresh fruits, apples and bananas for energy and oranges for vitamins are relatively cheap, depending, as always, upon the season and place.

With regard to vegetables, potatoes are cheap sources of energy and vitamin C, while cabbage and turnips are cheap sources of mineral salts and vitamins. Whenever it is financially possible to increase the vegetable intake one should not forget that broad beans, peas and lentils are excellent sources of energy, mineral salts and vitamins. Table 37 shows the comparative value of certain of the vegetables in regard to protein, calories, minerals and vitamins. Higher income groups always tend to provide more protein, particularly animal protein, vitamins and minerals relative to the calorie value of the diet than the lower income groups, where the chief deficiencies are in animal protein, vitamins A and C, riboflavin and calcium. It is, however, true in this country, and also on the North American Continent, that all the deficient dietaries are not found among the low income groups.

Guides to Dietary Planning.—A consideration of Tables 38 to 43 will give some indication of the basic structure of diets, but, in order to plan meals which are both nutritious and palatable, more detailed information is required concerning the art of menu building. The housewife does not buy calories, proteins and vitamins, but sugar, meat, potatoes and salt, and many other items of a diet before facing the question of the preparation and cooking of a meal for a family more difficult to feed than to describe in terms of man values. Standard allowances

in terms of nutrients are of little value to the housewife faced with the problem of feeding two or three healthy children. The problem is essentially one of the quantity and quality of food. It is therefore necessary to give guidance in the formation of menus. Much good advice on food planning has been disseminated during the war years by the Ministry of Food, and numerous publications have been made available for all interested in dietetics. To show how important is a knowledge not only of the constituents but the composition of a meal, the following quoted from the Ministry of Food *Manual of Nutrition* (1945) may be instructive.

"It is quite common to find that in a factory two 'communal' meals are provided during the morning. The first, let us say, consists of a 'cheese roll' and a cup of tea. Where there is ignorance of nutrition, this could be forgotten or, at least, not considered to be a meal at all. The second might consist of roast mutton, cabbage and potatoes, followed by stewed apples and custard. The nutritional value of these two meals as eaten has been calculated and are :—

MEAL I

	Weight oz.	Calories	Protein g.	Fat g.	Calcium mg.	Iron mg.	Vit. A I.U.	Vit. B_1 mg.	Vit. C mg.	Vit. D I.U.
Roll (= bread)	3·5	252	8·4	1·4	56	1·7	0	0·19	0	0
Butter . .	0·3	63	0·3	7·0	1	0	342	0	0	5
Cheese . .	2·0	234	14·2	19·6	460	0·4	740	0·02	0	20
Tea . .	10·0	50	1·0	1·0	30	0	40	0	0	0
Total meal .	—	599	23·9	29·0	547	2·1	1122	0·21	0	25

"The tea, it should be mentioned, has milk and sugar added; the quantities have not been stated."

The comment is "that meal I may be dismissed as a mere 'snack', while it is 'in many ways of far higher nutritional value than the hot meal II since it provides twice as many Calories, almost three times as much protein and three times as much fat and four times as much calcium. The single nutrient in which the second meal is markedly superior to the first is vitamin C."

MEAL II

	Weight oz.	Calories	Protein g.	Fat g.	Calcium mg.	Iron mg.	Vit. A I.U.	Vit. B_1 mg.	Vit. C mg.	Vit. D I.U.
Mutton .	0·8	75	3·0	7·0	2	0·5	11	0·04	0	0
Cabbage .	3·0	21	1.2	0	54	0·9	255	0·06	24	0
Potato .	4·0	84	2·4	0	8	0·8	0	0·13	4	0
Apples .	3·0	36	0·3	0	3	0·3	12	0·04	1	0
Custard .	2·0	66	1·8	2·2	70	0	40	0·01	0	0
Total meal .	—	252	8·7	9·2	137	2·5	318	0·28	29	0

The objection, however, may be raised that 0·8 oz. of mutton is an extremely small amount of meat and does not represent the usual amount of meat or mutton eaten at dinner. If 2·4 oz. be accepted as constituting a fair comparison we have :—

MEAL II*a*

	Weight oz.	Calories	Protein g.	Fat g.	Calcium mg.	Iron mg.	Vit. A I.U.	Vit. B_1 mg.	Vit. C mg.	Vit. D I.U.
Mutton . .	2·4	225	9·0	21·0	6	1·5	33	0·12	0	0
Total . .	—	477	17·7	30·2	143	4·0	351	0·40	29	0

As a factory "communal" meal the first is much better than the second in terms of Calories, calcium and vitamin A. If one-third of a pint of milk were added to meal I it would be far superior to meal II*a* as is shown by the figures :—

MEAL I*a*

	Weight oz.	Calories	Protein g.	Fat g.	Calcium mg.	Iron mg.	Vit. A I.U.	Vit. B_1 mg.	Vit. C mg.	Vit. D I.U.
Milk . .	6·6	120	6·3	7·0	226	0	266	0·086	2·0	2
Total . .	—	719	30·2	36·0	773	2·1	1388	0·296	2·0	27

It is important not to forget the purpose for which the meal is planned. That the first meal is superior in calories is due to 51 grams of carbohydrate in the roll and 19 grams of fat in the cheese. The second meal in its original form is of comparatively little value; in its second form its chief contribution is 17·7 grams of animal protein and therewith valuable extractives, iron and vitamin C. Comparisons are excellent, particularly if they emphasize the value of both types of meal, i.e. I*a* and II*a* in the daily dietary.

To guide effectively in the planning of meals one must know the nutrient content of the foods to be chosen and the reason for the choice. Without such knowledge neither the quantity of the foods required nor the quality of the meal proposed can be accurately known. While it is the duty of the dietitian to plan the menus in accordance with the knowledge gained from such calculations, it is none the less the duty of the physician, surgeon or nutritionist to be prepared by such means, to state in exact terms the amounts of the essential nutrients required by patients in their care. The planning of diets for men and women living under various conditions of activity, for infants, children, adolescents and elderly people, as well as the therapeutic use of diets, are fully described in text books on dietetics to which references are given.

BUDGETARY AND DIETARY SURVEYS OF LOW INCOME GROUPS

The manner in which diets have been planned in relation to the cost and availability of food during the period of the war has been investigated by numerous Budgetary Surveys. These surveys have shown that the great majority of families faced the problems of war-time catering and cooking with initiative, and doubtless they will continue to do so throughout the lean years ahead. In the case of the lowest income groups the problem is always one of real hardship and difficulty in that the purchase of food conflicts with the purchase of other things. Combined Budgetary and Dietary Surveys of low income groups all too clearly show how an adequate diet becomes inadequate in the presence of rags, a single gas ring and a lack of accommodation. In the presence of an inadequate purchasing power, the interrelatedness of food, clothing, housing, insurance,

recreation, etc., becomes strikingly apparent. The results of these surveys emphasize the urgency of planning for better nutritional and social conditions for the lower income groups of the nation. They reveal how closely the attainment of dietary standards is linked with the purchasing power of low income groups, for the cost of food cannot be dissociated from the cost of other basic needs.

To decide whether the amount of money spent on food in any family group is sufficient, it is essential to know (*a*) the man value of the group, (*b*) the dietary requirements of the group and (*c*) the cost of the food necessary to meet the requirements. Knowing the cost of the food, one may in very broad terms state what should be the minimal or basic income of the family. In view of the great variations which obtain in rents, rates and taxes, these should not be included in any statement of the basic income.

(*a*) **The Man Value of the Group.**—For all practical purposes, it is sufficient, in assessing man values, to use the factor 0·65 for all members of the family *under* 14 *years of age* and 1 for all who are 14 years and over. Thus for a family of two parents and three children under 14 years of age, the man value is $2 + (3 \times 0{\cdot}65) = 3{\cdot}95$. For two parents, one adolescent over 14 years of age and two children the factors are $2 + 1 + (2 \times 0{\cdot}65) = 4{\cdot}30$. These factors were used in budgetary and dietary surveys carried out by the Aberdeen branch of the Children's Nutrition Council and were found to give a good approximation to the man values calculated by more detailed factors for age groups (Cathcart *et al.*).

(*b*) **The Basic or Minimal Diet.**—Having decided on the factor for the members of the family, it is necessary to obtain a monetary standard, a figure which will cover the minimal expenditure, rent and taxes excluded, on food, clothing, fuel and light, and household and personal sundries. In assessing the amount of money which should be available for family needs after rents, rates and taxes have been paid, the first and most important consideration is the cost of an adequate diet. It may well be argued that the cost of food determines the standard of living and must therefore bear a definite relation to the basic income. The generally accepted minimal dietary standard is that published by the British Medical Association in 1933, Table 42. The comparative costs (1933 to 1945) of

Table 42

ADULT RATION FOR ONE WEEK SUGGESTED AS ADEQUATE BY THE B.M.A.

Based on 50 *grams First Class Protein, giving* $\frac{1}{4}$ *Pint Milk Daily, Man-value* 1, *with the* 1933 *B.M.A., and the November* 1940 *and October* 1945 *Edinburgh Prices of the Foods included*

Food	Weight of Weekly Allowance 1933	B.M.A. 1933 cost	Edinburgh Nov. 1930 cost	Edinburgh Oct. 1945 cost
		s. d.	s. d.	s. d.
Beef	1 lb.	0 6	1 4	1 8
Minced meat	$\frac{1}{2}$ lb.	0 $2\frac{1}{2}$	0 6	0 8
Bacon	$\frac{1}{2}$ lb.	0 3	0 $9\frac{1}{2}$	1 2
Corned beef	$\frac{1}{2}$ lb.	0 3	0 8	0 10
Liver (ox)	$\frac{1}{4}$ lb.	0 $1\frac{3}{4}$	0 $3\frac{1}{2}$	0 $3\frac{1}{2}$
Eggs	2 oz.	0 1	0 3	0 2
Cheese	$\frac{1}{2}$ lb.	0 $3\frac{1}{4}$	0 $6\frac{1}{2}$	0 $6\frac{1}{2}$
Milk	$1\frac{3}{4}$ pts.	0 5	0 7	0 $7\frac{1}{2}$
Fish (cod)	$\frac{1}{4}$ lb.	0 $1\frac{1}{4}$	0 $4\frac{1}{2}$	0 5
Butter	$\frac{1}{4}$ lb.	0 $2\frac{1}{2}$	0 $4\frac{3}{4}$	0 5
Suet	1 oz.	0 $0\frac{1}{4}$	0 $0\frac{1}{2}$	0 $1\frac{1}{4}$
Lard	$\frac{1}{4}$ lb.	0 $1\frac{1}{2}$	0 2	0 $2\frac{1}{4}$
Flour or	$4\frac{1}{2}$ lb.	1 $0\frac{1}{2}$	1 $1\frac{1}{2}$	1 1
Bread	$7\frac{1}{4}$ lb.	1 $0\frac{1}{2}$	1 $1\frac{1}{2}$	1 $6\frac{1}{2}$
Sugar	1 lb.	0 $2\frac{1}{4}$	0 $4\frac{1}{2}$	0 4
Jam	$\frac{3}{4}$ lb.	0 $3\frac{1}{4}$	0 $6\frac{1}{2}$	0 9
Potatoes	5 lb.	0 $3\frac{3}{4}$	0 $5\frac{3}{4}$	0 $6\frac{1}{2}$
Peas (dried)	$\frac{1}{4}$ lb.	0 1	0 2	0 $2\frac{1}{2}$
Tea	$\frac{1}{4}$ lb.	0 3	0 $6\frac{3}{4}$	0 10
Oatmeal	$\frac{1}{2}$ lb.	0 $1\frac{1}{4}$	0 $1\frac{3}{4}$	0 $1\frac{3}{4}$
Yeast	1 oz.	—	—	0 $1\frac{1}{2}$
Rice	$\frac{1}{4}$ lb.	0 $0\frac{3}{4}$	0 $1\frac{3}{4}$	0 $1\frac{1}{2}$
Syrup (treacle)	$\frac{1}{2}$ lb.	0 2	0 3	0 $4\frac{1}{4}$
Cabbage	1 lb.	0 1	0 $2\frac{1}{4}$	0 $3\frac{1}{2}$
Beans (butter)	$\frac{1}{4}$ lb.	0 $0\frac{3}{4}$	0 $1\frac{3}{4}$	0 $1\frac{1}{2}$
Barley	$\frac{1}{2}$ lb.	0 1	0 1	0 $3\frac{1}{2}$
Fresh fruit and green vegetables	—	0 7	2 4	2 4
Margarine	$\frac{1}{4}$ lb.	—	—	0 $2\frac{1}{2}$
Total weekly cost	—	5 $10\frac{1}{2}$	12 $6\frac{1}{2}$	15 $3\frac{1}{2}$

the foods composing this diet show how prices have altered since 1933. The British Medical Association diet priced in Edinburgh, in 1933, was 5s. $10\frac{1}{2}$d.; 1936, 6s. 6d.; 1940, 12s. $6\frac{1}{2}$d.; and in 1945, 15s. $3\frac{1}{2}$d. The weekly meat allowance of 1s. 2d.,

with the cost of 4 oz. of bacon and 4 oz. of liver, i.e. 10½d., permit a weekly expenditure on meats of 2s. 0½d., that is, 2s. 7d. less than recommended under the British Medical Association allowance. On a British Medical Association dietary basis the total cost of the foods now available would be 15s. 3½d.— 2s. 7d. = 12s. 8½d. per head per week (i.e. in Edinburgh Oct. 1945).

The cost of the diet in surveys made in Scotland in 1941 was 6s. 11d. per head per week, that of low income groups with allotments, 6s. 2d., without allotments 7s. 5d. per head per week. In low income groups in 1942, the cost had risen to 7s. 4d. per head per week. The estimated cost of a basic war-time diet in Aberdeen in 1942 was 8s. 9d. *per man value* per week. The estimated cost of the same basic diet in October 1945 was 10s. *per man value* per week (Table 43).

In arriving at the standard cost of this basic diet no account was taken of the amounts of milk available to certain priority groups at lower prices. The money equivalent of the dietary standard was related to ordinary retail prices and therefore in computing the equivalent *expenditure on food per man value per week,* allowance was made for priority classes by adding to the food expenditure the market value of free supplements or the difference between the amount paid and the market value of the supplements. This figure represents the true money equivalent of food expenditure per man value per week. It cannot be too clearly emphasized that while the cost of the diet is the basis upon which the standards of necessity are calculated, the figure given, namely 10s. per week, is not to be regarded as the amount of money for which this diet can be secured at all times and in all places. The cost of the basic diet must first be determined for each area or community where such standards are to be applied.

(*c*) **The Basic or Minimal Income per Man Value per Week of the Group.**—This is based on the cost of an adequate diet for the family group. The extent to which the cost of an adequate diet has changed since the British Medical Association published the constituents of an adequate diet has been referred to. Having arrived at a fair cost for an adequate diet, one must decide what percentage this should be of the basic income. It was found in the budgetary and dietary survey (1942) of low income groups referred to that the families spent from 45 to

TABLE 43

A BASIC DIET FOR AN ADULT (MODERATELY ACTIVE)

Foods as Purchased Weekly	Quantity	1942 Cost	1945 Cost	Calories	Protein g.	Fat g.	Carbo-hydrates g.	Calcium g.	Iron mg.	A (I.U.)	B_1 (µg.)	C mg.
		s. d.	s. d.									
Milk	2 pts.	0 8	0 8	720	38	40	50	1·36	1·0	1,600	520	16
Meat	1 lb.	1 0	1 6	1,100	64	80	—	0·03	16·1	114	227	—
Bacon and ham	4 oz.	0 6½	0 7	448	11	45	—	0·01	1·2	—	600	—
Fish (fillets cod)	4 oz.	0 5	0 5	52	12	0·4	—	0·02	0·9	—	44	—
Cheese	4 oz.	0 4	0 3½	464	28	39	—	1·00	0·8	1,470	36	—
Eggs (powder)	=2 eggs	0 3½	0 2½	160	12	12	—	0·06	2·5	988	148	—
Fats—												
Butter	2 oz.	0 6	0 2½	422	0·2	47	—	0·00	0·0	2,272	—	—
Margarine	4 oz.	0 6	0 2½	872	0	96	—	—	0·4	2,272	—	—
Lard	2 oz.	0 6	0 1½	506	—	57	—	—	—	—	—	—
Bread, cakes, etc.	7 lb.	1 4	1 8	8,064	269	45	1,635	1·89	56·0	—	5,936	—
Flour	1 lb.	0 2½	0 3	1,568	49	11	345	0·08	6·4	—	384	—
Sugar	½ lb.	0 1½	0 2	864	—	—	216	—	—	—	—	—
Jam, marmalade	4 oz.	0 3½	0 3½	284	0·4	—	70	0·03	—	—	12	24
Potatoes **	7 lb.	0 8	0 8	1,792	45	—	392	0·23	11·2	—	2,912	672
Oatmeal	8 oz.	0 1½	0 1½	888	27	20	148	0·13	9·6	—	1,024	—
Cereals	8 oz.	0 6½	0 6½	776	31	6	150	0·08	11·2	—	88	—
Vegetables—		1 2	1 6									
e.g.—Carrots	4 oz.			20	0·8	—	4	0·05	0·4	18,000	56	8
Turnips	12 oz.			36	1·2	—	7	0·13	1·2	—	84	60
Cabbage	12 oz.			60	3·6	—	12	0·15	2·4	2,148	180	168
or * Brussels sprouts	12 oz.			84	10	—	10	0·07	3·6	1,020	312	256
Tea, condiments	4 oz.	0 6½	0 7									
Weekly		8 9	10 0	19, 096	592·2	498	3·178	5·26	121·3	28,864	12,251	948
Per day				2,728	84·6	71	454	0·75	17·3	4,123	1,750	135

Animal protein 27 grams per day.

** Or lentils or peas in the form of soups.

Wastage: potatoes, 15%; carrots, 11%; turnips, 17%; cabbage, 17%; Brussels sprouts, 17%.

Possible additions for optimal diet—

Food per Week	Quantity	Cost	Calories	Protein g.	Fat g.	Carbo-hydrates g.	Calcium g.	Iron mg.	A (I.U.)	B_1 µg.	C. mg.
Beef, stewing steak .	½ lb.	—	480	38	36	0	0·024	8·8	112	184	0
Beef steak . .	½ lb.	—	720	32	65	0	0·024	8·9	112	184	0
Beef, canned (corned)	4 oz.	—	276	28	18	0	0·012	12	0	0	0
Tongue . . .	4 oz.	—	292	21	23	0	0·012	3·6	0	320	0
Liver (ox) . .	4 oz.	—	160	19	6	5	0·012	15	17,040	456	0

60 per cent of their available income on food. The cost of the basic diet was 8s. 9d., and it was accepted that this expenditure on food should be 55 per cent of the net or basic income which was therefore 16s. per man value per week. It was emphasized at the time that this method of arriving at a minimal standard of necessity was only applicable to families of three or more persons.

What obtained in 1942 is clearly not applicable to conditions in 1945. Social conditions in many of the lowest income groups make for almost insurmountable difficulties in buying and cooking an adequate diet, particularly in families where there are many young children. In not a few families, where the gross income is good, the money available to the mother to fulfil her household duties is pitiably inadequate. A full realization of the difficulties which beset many low income families demands an up-to-date estimate of the cost of an adequate diet. In notes on working class expenditure Professor Bowley reports on the results of a budgetary survey organized by the Oxford University Institute of Statistics in which the average weekly food expenditure of working class families in May 1940 was 9·3 shillings per "man" value per week; the man values being for a male over 14 years, unity, for a female over 14 years, 0·85, and for children, 0·55. In a second survey, October 1940, the average weekly expenditure on food was 9·17 shillings, rent 3·01 shillings, clothing, fuel, household and miscellaneous expenses 8·88 shillings.

Under conditions obtaining in Aberdeen in October 1945, the cost of the basic adequate diet was 10s. per man value per week, a cost which should be accepted as 50 per cent of the basic income, which therefore becomes 20s. per man value per week. The factors for other expenditure shown in Table 44

Table 44

FORMULÆ FOR ASSESSING STANDARDS OF SUBSISTENCE IN FAMILY GROUPS

The Estimated Cost of a Basic Diet = 10s. per man value per week
= 50 % of the Basic Income.

Basic Income, shillings per man value per week = 10 × 2 × man value.

Man values = Adults and adolescents 14 years and over = 1
All children under 14 years = 0·65

Factors for Clothing = 3·0 Fuel and light = 2·0
Household sundries = 1·5 Personal sundries = 3·0

Note.—Any change in the cost of the basic diet demands a corresponding change in the factors.

Example.—If the diet costs 12s., the basic income and all factors must be increased 20 per cent.

	A. Family of 1 Man value = 1	B. Family of 2 1 1 adult, 1 adol. Man value = 2	 2 1 adult, 1 child Man value = 1·65
1. Basic Income	= 10 × 2 = 20	10 × 4 = 40	33·0
2. Food	= 10 × 1 = 10	10 × 2 = 20	16·5
3. Clothing	= 3·5 × 1 = 3·5	3·5 × 2 = 7	5·7
4. Fuel and light	= 2·0 × 1 = 2·0	2·0 × 2 = 4	3·30
5. H. sundries	= 1·5 × 1 = 1·5	1·5 × 2 = 3	2·45
6. P. sundries	= 3·0 × 1 = 3·0	3·0 × 2 = 6	4·95
	= 20 + 20s.	= 40 + 10s.	33·0 + 10s.

C. Family of 3

	1 2 adults 1 child Man value = 2·65	2 2 adults 1 adol. Man value = 3	3 1 adult 2 children Man value = 2·3
1.	53·0	60·0	46·0
2.	26·5	30·0	23·0
3.	9·3	10·5	8·1
4.	5·3	6·0	4·6
5.	4·0	4·5	3·4
6.	7·9	9·0	6·9
	53·0	60·0	46·0

D. Family of 4

	1	2	3	4
	2 adults 2 children Man value = 3·3	2 adults 1 adol. 1 child Man value = 3·65	2 adults 2 adol. Man value = 4	1 adult 3 children Man value = 2·95
1.	66·0	73·0	80·0	59·0
2.	33·0	36·5	40·0	29·5
3.	11·5	12·8	14·0	10·3
4.	6·6	7·3	8·0	5·9
5.	5·0	5·5	6·0	4·5
6.	9·9	10·9	12·0	8·8
	66·0	73·0	80·0	59·0

E. Family of 5

	1	2	3	4	5
	2 adults 3 children Man value = 3·95	2 adults 1 adol. 2 children Man value = 4·3	2 adults 2 adol. 1 child Man value = 4·65	2 adults 3 adol. Man value = 5	1 adult 4 children Man value = 3·6
1.	79·0	86·0	93·0	100·0	72·0
2.	39·5	43·0	46·5	50	36·0
3.	13·8	15·0	16·2	17·5	12·6
4.	7·9	8·6	9·3	10	7·2
5.	6·0	6·5	7·0	7·5	5·4
6.	11·8	12·9	14·0	15	10·8
	79·0	86·0	93·0	100·0	72·0

F. Family of 6

	1	2	3	4	5
	2 adults 4 children Man value = 4·6	2 adults 1 adol. 3 children Man value = 4·95	2 adults 2 adol. 2 children Man value = 5·3	2 adults 3 adol. 1 child Man value = 5·65	2 adults 4 adol. Man value = 6·0
1.	92·0	99·0	106·0	113·0	120·0
2.	46·0	49·5	53·0	56·5	60·0
3.	16·1	17·4	18·5	19·8	21·0
4.	9·2	9·9	10·6	11·3	12·0
5.	6·9	7·4	8·0	8·5	9·0
6.	13·8	14·8	15·9	16·9	18·0
	92·0	99·0	106·0	113·0	120·0

are naturally generalizations, and the whole method affords but a practical approach to the assessment of what may be regarded as a minimal standard of living.

Having regard to the findings of these surveys and to the present cost of living and, with it, the increase in the cost of food, it becomes necessary to change the 1942 factors for calculating the expenditure on clothing, fuel and light, household and personal sundries. The change in the ratio of the national expenditure upon these items between 1938 and 1943, with the corresponding ratio for the Oxford Survey of 1940

TABLE 45

PERCENTAGE DISTRIBUTION OF EXPENDITURE ON CLOTHING FUEL AND LIGHT, HOUSEHOLD AND PERSONAL SUNDRIES

Article	From Statistics for U.K.		"Oxford Statistics" 1940	C.N.C. 1942	Suggested for Calculation of Expenditure
	1938	1943			
Clothing	35	38	23	31	35
Fuel and light	16	28	20	21	20
Household sundries	19	9	9	13	15
Personal sundries	30	25	48	35	30

and the Aberdeen survey in 1942, is shown in Table 45. The suggested percentage distribution of expenditure given in column 5 is the result of surveys carried out in Aberdeen.

That the standards detailed in Tables 44, 45 and 46 are of practical value is shown by a consideration of the weekly expenditure of selected households. In 1937–38 the Ministry of Labour (1940) made a survey of household expenditure in industrial and agricultural areas and in villages in England and Wales. In 1938 Mr. Philip Massey made a survey of the expenditure in higher and middle economic groups, the results of which are shown in columns 2 and 3, Table 46. These surveys indicate quite clearly the distribution of expenditure upon food, clothing, fuel and light, miscellaneous items and rent and rates in middle and better class families. Expenditure is an excellent index of living conditions and it is therefore valuable to compare the results of these surveys with those of Mr. D. Caradog Jones (1934 and 1941) and the subsistence standards in Sir William

HOUSEHOLD EXPENDITURE

1 Items of Expenditure	2 Income £700 or more (Massey 1942)	3 Public Officials (Massey 1942)	4 Industrial Families (Ministry of Labour 1940)	5 Subsistence Standards (Cruickshank 1945)		6 Subsistence Standards (Jones 1941)	7 Subsistence Standards (Beveridge corrected for 1942)	8 Income 20 per cent below Poverty Line (Jones 1934)
A. A Comparison of Weekly Expenditure in Different Economic Groups								
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Rent and rates .	34 10	21 1½	10 10	10 6	10 6	8 6	10 0	8 9
Food . . .	64 7	41 10	34 1	33 0	39 6	30 8	24 1	17 1
Clothing . . .	26 7½	15 6	8 1	11 6	13 9½	11 1	5 0	1 6½
Fuel and light . .	16 2	10 1	6 5	6 7	7 11	5 4	4 5	4 0
Miscellaneous . .	179 6	83 7	25 7	14 11	17 9½	13 5	7 0	2 6½
Total . . .	321 8½	172 1½	85 0	76 6	89 6	69 0	50 6	33 11
Average number of persons per household .	3·97	3·27	3·77	4·0	5·0	5·0	3·77	6·18
B. Percentage Distribution of Expenditure								
Rent and rates .	10·8	12·3	12·7	13·7	11·7	12·3	19·8	25·8
Food . . .	20·1	24·3	40·1	43·1	44·1	44·5	47·7	50·4
Clothing . . .	8·3	9·0	9·5	15·0	15·4	16·7	9·9	4·5
Fuel and light . .	5·0	5·9	7·6	8·7	8·8	7·8	8·7	11·8
Miscellaneous . .	55·8	48·5	30·1	19·5	20·0	18·7	13·9	7·5
Total . . .	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0
C. Percentage Distribution of Expenditure. Rent and Rates being Deducted								
Food . . .	22·4	27·7	45·9	50·0	50·0	50·6	59·6	67·9
Clothing . . .	9·3	10·2	10·9	17·5	17·5	18·1	12·1	6·1
Fuel and light . .	5·6	6·7	8·8	10·0	10·0	8·9	11·0	15·9
Miscellaneous . .	62·7	55·4	34·4	22·5	22·5	22·4	17·3	10·1
Total . . .	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

Beveridge's report on *Social Insurance and Allied Services.* The average figures of these surveys are given in Table 46, columns 6, 7 and 8.

The Beveridge subsistence standards are based on the usual expenditure found and not on what may be considered necessary. It is important to bear in mind the date of any survey, and to remember that standards require readjustment in an ever-changing world. Noteworthy in Table 46 are the trends in expenditure. Despite an appalling drop in the expenditure on food, rent and rates, as one descends the economic scale the expenditure on these items claims 75 per cent of the total income. Under economic conditions, such as these figures portray, the expenditure most necessary, after food, rent and rates, must needs be on fuel and light. Inadequate clothing demands more heat, just as the inadequate basic incomes precludes the purchase of many of the necessities and amenities of life. While in the lower income groups 50 per cent of the total income should be spent upon food the percentage so spent naturally becomes less as the available income increases. In view of the need for better clothing for all members, and particularly the children, of the lower income groups, the amount spent on clothing should be greater than the usually recorded 10 per cent. The percentage distribution of expenditure on rent and rates, food, clothing, fuel and light and household and personal sundries (i.e. miscellaneous items) is shown in Table 46B. Since rent and rates vary considerably it is advisable to deduct these from the total income and this has been done in presenting the percentage expenditure distribution in Table 46C. Column 5 of Table 46C is taken from the data for two families, one of two parents and two children the other of two parents and three children, the man value of these two families being 3·3 and 3·95 respectively (see Table 44 : Families of 4 and 5 persons).

In comparing various standard scales for relief benefits two points are noteworthy; first, basic or net incomes should not include rent and rates: rents, varying greatly, and better housing, involving the payment of higher rents, should not be allowed to encroach upon the limited purchasing power of a net income; second, it is imperative in dietary surveys that the composition of the family be considered. Practical standards or "yardsticks" must naturally be flexible; the crucial test would appear to be the manner in which they

measure the needs of families of four or more persons. The family most suitable for testing standards consists of father, mother and three children. For adults living alone, for groups of two adults, and families of one adult and one child, monetary additions to the suggested scales must be made according to the circumstances of the case. They should never be less than those recommended in Table 44. In low income families a well balanced budget should not be regarded too highly. Families on or below the basic income rates given in Table 44 are, if not in debt, never very far from it. Theirs is a very precarious existence, and if they approach a good expenditure on food, it is certainly at the expense of clothing and other essentials. Debt is rarely, if ever, due to any undue expenditure upon food. This method of investigation, namely, by the use of a monetary standard based on the cost of an adequate diet and on factors for determining the minimal expenditure within the family should be of some value to Education Authorities, Public Assistance and other bodies, in deciding conditions of necessity where consideration is being given to the issue of free milk, meals, boots and clothing and in determining the extent and distribution of bursaries, scholarships and grants to boys and girls of ability in elementary schools.

From intimate knowledge of the living conditions of men, women and particularly children, the opinion grows ever stronger that instruction in the elementary principles of healthful living should be an integral part of our educational system. By this is meant that all children should be taught the elements of hygiene, the nutritive value and comparative cost of the chief foods, how to cook them so that essential nutrients should not be damaged, and should learn something of the elementary physiological needs of the body for growth and the maintenance of health. It is probably not too much to say that this may prove to be a fundamental factor in securing the disappearance of the low income family from our midst. For many parents to-day the feeding of their children is a financial problem which demands courage, selflessness and sacrifice. The solution of the problem of national nutrition depends upon an adequate production and equitable distribution of food. In the final analysis these are economic problems and, as such, can only be satisfactorily solved when the nutritional needs of world populations are regarded as a whole.

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CHAPTER XVI

DEHYDRATION AND PRESERVATION OF FOODS

THE preservation of foodstuffs by drying is no new idea. It is part of nature's process in maintaining the living state, as is seen, for example, in grains and the spores of micro-organisms which lie dormant in a state of desiccation until the time of germination by means of moisture, has arrived. In America and Africa natives have from the remote past preserved meat by drying it in the sun. The pemmican of the North American Indians, the biltong of the South African natives and the charqui of the South Americans are well known. The dried fruits—apricots, dates, figs, prunes and raisins—have been known from ancient times, as has also been the storing of grain against human need. For centuries fish has been preserved by exposure to sun and wind or by heating. In the Far East the drying of fish is an important industry. On the North Atlantic coasts fresh and salted cod fish are dried, the fresh dried fish, called " stockfish ", is hard and brittle, the salted fish, only partially dried and containing about 40 per cent of water, is comparatively soft. In North American countries the drying of fish is usually associated with heavy salting and smoking. These methods, uncontrolled as to temperature, humidity and time, are productive of a tough texture and strong characteristic flavours which persist after reconstitution and cooking. It can safely be said that none of the dried foods—meat, fish, fruits, milk, eggs and vegetables—in which people are interested to-day have, in the past, possessed qualities which entirely recommended them to the general public. Until recently no intensive research had been undertaken to determine the various conditions under which drying would produce an article of diet, the flavour, nutritive value and keeping qualities of which would be adequately preserved. In 1939 the outbreak of war brought the people of this country face to face with the greatest of all dangers which could confront them, namely the threat of destruction of all imported foods. In view, not only of this danger, but of the pressing need of shipping space it became imperative that the problem of

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dehydration of foodstuffs should receive immediate attention. Under the chairmanship of Sir Joseph Barcroft, F.R.S., the Food Investigation Board, of the department of Scientific and Industrial Research, undertook to discover how best, in the realm of food, to economize in weight, space and labour, and thus help to solve some of the problems of the transport and storage of food in order that the armies abroad, and the people and the armies at home, should be well fed. The work on the drying of food organized by Mr. Eric Barnard, Director of Food Investigation, was conducted under the scientific leadership of Dr. Franklin Kidd, at the Low Temperature Research Station, Cambridge and under Dr. G. Reay at the Torry Research Station, Aberdeen. The effect of oxygen in causing deterioration of dried foodstuffs was investigated by Dr. Moran and others at the Low Temperature Research Station, by Professor H. D. Kay, F.R.S. and Dr. S. L. Kon at the National Institute for Research in Dairying, Reading, with the co-operation of commercial firms and by Dr. N. C. Wright and Dr. J. A. B. Smith of the Hannah Dairy Research Institute, Ayr, and many others. Dehydration by a vacuum-oil technique has also been achieved by Dr. B. S. Platt of the Human Nutrition Research Unit of the Medical Research Council. The full story of the scientific results obtained has yet to be told, only brief reference to its salient features can be given here.

THE PRINCIPLES OF FOOD DEHYDRATION

In chemistry, dehydration is the removal of water from a compound. Freezing may be regarded as dehydration, since the water in the food-stuff has been deposited as ice crystals and can take little or no part in chemical changes, which may still proceed at the freezing point. That changes do take place at or below freezing point, is indicated by the development of unpalatable flavours in frozen food. These "off" flavours are due to the presence of enzymes or ferments which are not destroyed by freezing. The chief reason for removing water is to prevent bacterial action which may destroy the food, render it unpalatable and even dangerous.

It becomes necessary therefore before freezing to kill the enzymes; this is done by pre-heating, scalding or blanching. The means whereby the frozen water is removed without thawing

is to sublime the ice in a vacuum at $-20°$ C., and the vapour condenses on refrigerating coils at a temperature of about $-40°$ C. Foodstuffs dried in this way retain their flavour, keeping qualities, appearance and vitamins. All the principal foods have been experimentally dried *in vacuo*. This method of dehydration was not used on an extensive commercial scale during the war, the development of the necessary industrial plant being largely a peace time project.

Oxygen is a very potent factor in causing deterioration of food, fresh or dried ; it must be removed, if not wholly, at least to a very great extent if a foodstuff is to retain its essential qualities for long periods, e.g. twelve months or two years. Oxygen can be removed by replacing it with an inert gas such as nitrogen. Anti-oxidants may be added to the dried food or the anti-oxidants present in foodstuffs may be utilized to render dried foods more stable. The action and the use of anti-oxidants are receiving the attention of food chemists. If pre-heating is an initial step in dehydration, the simple air drying procedures can be successfully applied to meat, fish and vegetables. The finished product must be packed in an air-tight container, and in nitrogen, if it is to be stored for more than two months. Foodstuffs so prepared are, when reconstituted, characterized by excellent flavour and keeping qualities.

In drying it is important that temperature changes be controlled otherwise overheating or scorching damages protein and the nutritive value of the food suffers accordingly. It is also important that water should be removed as quickly as possible and this can be well done by vacuum methods. Warmth coupled with humidity enhances bacterial growth ; the dried article must therefore be protected from moisture as well as from oxygen. To secure the best results in dehydration these principles must be adhered to ; and it almost goes without saying that the best in quality, appearance and palatability will never be attained unless the fresh foodstuff is of the best. Dehydration must never be permitted to become a means of marketing foods which, in their fresh state, have so deteriorated that they are not acceptable to the public.

Methods and Apparatus.—Two methods are employed for drying foodstuffs, (1) direct contact with a heated surface and (2) contact with dry heated air (see Fig. 35).

In the first method, the foodstuff may be dried (*a*) in a simple

vessel heated by circulating steam, (*b*) in a rotary drier, where the foodstuff is stirred by revolving paddles and (*c*) on rollers, in pairs, heated by steam, the dried material being removed by suitably adjusted knives. In the second method the foodstuff may be dried (*a*) in trays placed in a cabinet or tunnel, through which heated air is passed over the foodstuff, (*b*) on a conveyor band, the warm dry air passing upwards through the foodstuff and (*c*) by spraying liquid foodstuff into a large chamber through which air is forced, the sprayed material being collected at the bottom of the chamber. The method to be used is determined by the nature of the foodstuff to be dehydrated, the temperature being at no time high enough to damage the foodstuff physically or nutritionally.

MEAT

A standard process for the dehydration of meat has been developed in Britain at the Low Temperature Research Station of the Department of Scientific and Industrial Research. It is now used in New Zealand and Argentina. In dehydration the raw meat is first removed from the bone, cut into $\frac{1}{4}$ lb. slices, and cooked in open pans in a minimal amount of water or in steam at low pressure, the cooking being only sufficient to brown the meat. It is then coarsely minced, spread on trays and dried in a cabinet (Fig. 35, Group 2, Type 1) at 60°, or at 70°–80° C. under a slight vacuum; it suffers very little loss of nutritive value. Humidity and temperature are controlled. At the be-beginning of drying the dry bulb temperature is 80° C. and the wet bulb temperature 55° C.; at the later stages of drying the dry bulb temperature is reduced to 70° C.: this prevents scorching of the dried product. The process is generally completed in 5 hours. Temperatures rising higher than 80° C. have a progressively bad effect upon the biological value of meat proteins. At temperatures up to 80° C. in the chamber there is no loss of vitamin B_1; above this, for example, at 100° C., the loss may be 70 per cent, while at 125° C. the vitamin is completely destroyed. While these figures represent losses in the drying chamber, it must be noted that the previous heating of the meat for some 15 minutes, until it is brown, causes a loss of from 30 to 50 per cent of vitamin B_1. There appears to be no difficulty in retaining palatability and flavour. To retain a normal texture is a difficult problem. It is best retained by drying in

a current of air in a tunnel, or on a conveyor belt. All cooking liquors are collected, concentrated and spread on the drying meat and thus minerals are not lost from the dried product. Riboflavin and nicotinic acid are not apparently affected by drying. The fat content of dried meat ranges from 30 to 40 per

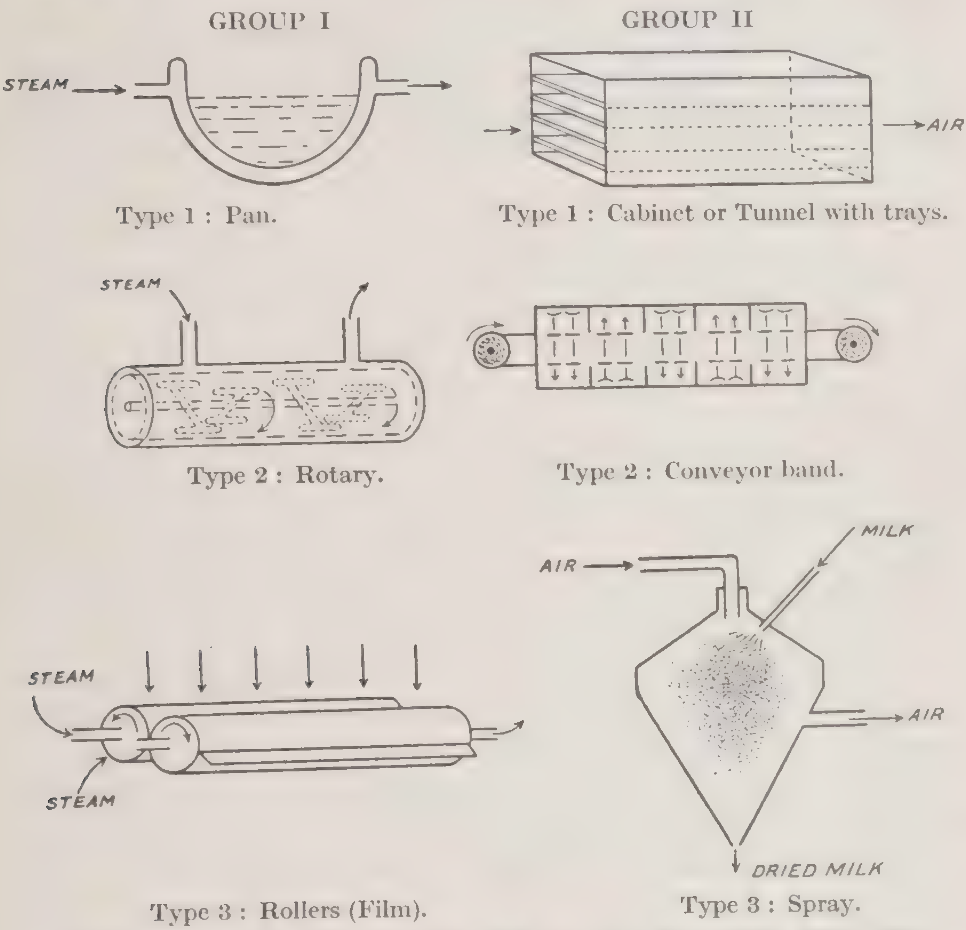

FIG. 35.—Methods of dehydration of foods (*after Bate-Smith, Sharp and E. M. Cruickshank*).

cent, this, with the added juices are of value in maintaining the natural flavour of meat. There should not be more than 7·5 per cent of water in the finished product ; if the water content be above 17 per cent on a fat-free basis, moulds will grow. Reconstitution and cooking of British standard dried meat present no difficulties and palatability is excellent, provided the dehydration has been carried out with attention to temperature, moisture and packing. In cooking, the amount of water used

should be three times the volume of the dried meat. To be assured that dried meat will keep well for a period of twelve months, it must be packed in air-tight tins with all the air replaced by an inert gas. If there be any oxidation of fat, the meat may become rancid, moulds may develop and free fatty acids may be formed.

The value of a dried meat product, in the saving of weight and space in the transportation of food in war time, is indicated by the changes in weight and bulk of fresh meat subjected to boning, tinning and drying shown in Table 47.

TABLE 47

SHOWING THE EFFECT ON WEIGHT AND SPACE OF THE VARIOUS METHODS OF TREATING BEEF
(From Sir Joseph Barcroft, F.R.S.)

	Weight (lbs.).	Bulk occupied (cub. ft.).
Side of beef	150	6·3
Boned	112	3·0
Tinned	120	2·6
Dried and blocked	44	1·0

In terms of shipping space the effect is at once apparent; refrigerated ships required for frozen meat can be dispensed with, and for every three of them required for the transport of boneless frozen meat only one unrefrigerated ship is required for the dehydrated meat, and the amount of water carried is reduced to a negligible fraction of the total weight.

EGGS

Eggs have presented difficulties in dehydration. Besides palatability, dried egg powder should retain the physical properties which make eggs valuable in aerating and binding the mixture in making cakes, and in moistening the baked product so that it will keep for many weeks if properly stored. Spray drying, since it entails the least damage to protein, is the most suitable method for dehydrating eggs. Prolonged drying at temperatures of 50 to 55° C., as in the conveyor belt method, causes a considerable loss of vitamins, and so much denatura-

tion of the proteins that their characteristic value in cooking and baking is lost. This, however, does not occur if the egg be spray dried at a temperature not exceeding 70° C. There is no appreciable loss of vitamins A and D in spray drying ; there is some loss of vitamin B_1.

Overheating results in a loss of solubility of the proteins and causes the fat globules present in the fresh yolk to run together with the result that a layer of fat or cream forms on the surface of the reconstituted fluid. Much depends on the water content of the dried egg powder and the protection it is afforded against oxidation. If the water content is over 5 per cent and the storage temperature above 15° C., changes begin to take place during storage, which are responsible for the " off " flavours and the poor reconstitution qualities of the powder. These changes are due to the formation of fatty acids, the breakdown of lecithin and the denaturation of the proteins of the egg, particularly those of the yolk. In the yolk, lecithin and the protein, vitellin, are loosely combined to form lecitho-vitellin. On exposure to air or light, lecithins absorb oxygen and water, become darker and more viscid, and like fat, have the property of spreading on the surface of water and forming a film. The formation of fatty acids is therefore associated with the denaturation of the protein. Herein lies part at least of the reason for a failure of the egg powder to behave in cooking, exactly in the manner so characteristic of the fresh egg. If egg white is beaten, a stiff foam results ; this is due to the denaturation of the proteins which form films of solid particles enclosing air bubbles. If this aerating property be destroyed by exposure to too high a temperature, the change becomes evident when the powder is used in cooking.

In the dehydration of eggs, they are first broken, pulped under good hygienic conditions and the fluid sprayed into the drier (Group 2, Type 3) through which heated air is passed. The temperature of the air is such that the dried powder will have 5 per cent of water, thus temperature and rate of " throughput ", as it is termed, are closely related. Important also is the size of the particles of the spray in relation to the length of time they are exposed to the warm air. The product is of course warm when collected from the drier and should, therefore, be cooled, filled into air-tight containers, the air replaced by nitrogen and the tins hermetically sealed. In the tropics, with tem-

peratures approaching or above 25° C., deterioration is much more rapid, and to the changes mentioned are added changes in the carbohydrate of the egg powder. It has been suggested, as a result of experimentation, that the addition of lactose or cane sugar to the egg pulp improves the solubility and colour of the powder when exposed to tropical conditions. At present it is impossible, by the strict exclusion of oxygen and a lowering of the water content of the powder, to prevent these changes taking place at high temperatures. To secure a good quality dried egg powder which will keep for long periods, all the factors mentioned must be carefully considered.

When the war made it impossible for this country to import frozen liquid eggs and glycerinated egg yolks, largely used in baking and manufacture, the Scientific Advisers of the Ministry of Food, after consideration of the nutritive value of various egg powders and the types of plant available for drying eggs, decided to recommend the spray drying process largely used in U.S.A., Australia and South America. The spray drying process has played a most important part in our war time economy. So great has been the importation of dried egg powder from the United States and other countries—amounting now to almost one hundred thousand tons per annum—that in 1944 and 1945 the great lack of shell eggs was almost made good by the use of the dried product.

The saving in space and weight by dehydration of eggs is very great. The normal egg box contains 360 eggs, the food required to produce these 360 eggs weighs approximately 270 lb. and occupies about 6·0 cubic feet. In shell, 360 eggs weigh 57 lb. and occupy 2·4 cubic feet, as a loose powder they weigh 11 lb. and occupy 0·38 cubic feet, and as a compressed powder weighing 11 lb. they occupy 0·24 cubic feet (Kidd 1944). This means that one ounce of dried egg powder is equivalent to two shell eggs.

One of the most important problems connected with dried egg powder has been to determine a standard of depreciation in the dried egg powder prepared for domestic use. To assay the quality of the powder, tasting panels have been formed. These dried egg tasting panels at the Low Temperature Research Station in Cambridge used the following scale or flavour scoring chart. (Bate-Smith, Brooks and Hawthorne, 1943) :—

Fresh egg flavour	8 points
Very lightly " off " flavour	7 ,,
Definitely " off " but not unpleasant . . .	6 ,,
" Off " flavour and unpleasant	5 ,,
Increasingly strong and unpleasant . . .	3–4 ,,
Repulsive and unedible	2–0 ,,

Trials by tasting panels have shown that the level of acceptance by the domestic consumer is from 6 points upwards on this scale. A chemical test of quality may soon be developed, based on the fact that deterioration of the egg powder is associated with the production of acid from the glucose of the egg. (Fryd and Hanson, 1945.)

MILK

Two types of process are used in the drying of milk namely the roller (drum or film process) and the spray or atomizer process. (Group 1, Type 3 and Group 2, Type 3.) In the roller process the milk is distributed as a film on the surface of one or usually two steam heated rollers, the thin sheets of dried milk being removed by knife-edged scrapers. The product is seived to the required fineness of grain. In the drying process two methods are used, one in which the milk is heated to a high temperature at barometric pressure ; the other in which it is heated at a lower temperature but under greatly reduced pressure, indeed, almost *in vacuo*.

Differences in the methods of production determine differences in the physical character of the two products. The spray dried power, having a protein which dissolves readily in cold water and a fat which disperses easily, reconstitutes in a most satisfactory manner ; the roller dried milk is not quite so satisfactory. In a whole milk roller dried product the fat globules coalesce and rise to the surface of the fluid and, particularly if the drying has been carried out at a high temperature in air, the solubility of the proteins, and therefore their power to form a fine colloquial dispersion, is impaired ; the solubility is 75 to 85 per cent in cold water and 80 to 95 per cent in hot water. Roller drying, if it is to produce a dried milk at all comparable to spray dried milk, must be carried out *in vacuo*. If the milk has been exposed to too high a temperature the poorly reconstituted product will always have a cooked milk taste. The nutritive values of spray dried and *in vacuo* roller dried milk are almost the same ; both suffer some loss of vitamins. The former

loses 10 per cent of vitamin B_1, 20 per cent of vitamin C and the biological value of its protein is at least 95 per cent of the original milk protein ; the latter loses 15 per cent of vitamin B_1, 30 per cent of vitamin C and the biological value of the protein is not greater than 90 per cent. Vitamins A and D and riboflavin suffer no loss.

The Properties of Spray Dried Milk.—In the spray or atomizer process the milk, generally pre-condensed, is sprayed in the form of a fine spray or mist into a chamber through which a current of heated air is continually passing. The spray consists of minute droplets of milk, exposing a very large surface to the heated air. The result is that the water of the milk droplet is almost instantaneously evaporated, leaving a particle of dried milk spherical in shape, enclosing a correspondingly small bubble of air. The particle is about 0·002 inch in diameter, about one-tenth the size of the flakes of roller dried milk which have to be ground to pass through a sieve of 0·02 inch mesh. The spray dried product is light, the fat is well dispersed and the protein has suffered less change by denaturation, because produced at a lower temperature than that of the roller process. The chief aims in all drying is to maintain good keeping properties in the dried product and good flavour in the reconstituted milk. The keeping properties depend upon the control of oxidations in the dried milk. In 1926, it was observed that butter fat prepared from milk less than 12 hours old was less susceptible to oxidation than fat separated from milk one day old (Holm, Greenbank and Deysher). It was later discovered that preheating milk for 30 minutes at 181° F. before drying, gave a powder of better keeping properties than that obtained from milk pre-heated to 145°, 163° and 200° F. It is interesting to note that in order to obtain butter resistant to the development of oxidative taints in cold storage, the cream from which it is made should be pre-heated to 165° F. for 30 minutes or, and with even better results, to 180° F. for a few seconds, as in the flash pasteurization of milk (Scheib *et al.*, 1942). The pre-heating of milk and its effects on the keeping properties of the dried product have been fully studied by Mattick and several others (1945), who, in comparing the effects of pre-heating at 165° F. and 190° F., state that " the powders prepared from milk pre-heated at the higher temperature remained in good condition, on the average, for two or three times as long as did the powders

prepared from milk preheated at the lower temperature ". It has also been suggested that " the improvement is due to the more efficient destruction of oxidising enzymes present or produced in the milk by the growth of micro-organisms or the production in the milk of sulphydryl compounds by the action of heat on proteins, particularly the lactalbumin and the protein associated with the fat globules ". Supplementary to these findings are those of Findlay, Smith and Lea (1945) on the effect of antioxidants when present in dried milk, the antioxidant being added to the pre-condensed milk before spray drying. Numerous chemical substances have been investigated —ascorbic acid, gallic acid and its esters (methyl, ethyl, propyl, etc.), citric acid, potassium bisulphite, etc.—the best being ethyl gallate, with ascorbic acid a rather poor second. While it is perhaps disappointing that ascorbic acid has not proved so successful as the gallic acid ester, it may be remembered that gallic acid itself is widely distributed in nature as a constituent of tannins which is present in many vegetable foods and particularly in tea and is usually considered to be non-toxic.

The destruction of harmful enzymes, the production and addition of antioxidants bear a very definite relation to the change of flavour and taste. The cooked flavour and the boiled taste in the reconstituted powders are extremely difficult to assess. It would appear impossible to obtain a reconstituted milk of excellent keeping properties without introducing some slight change in flavour. There seems to be no doubt that during storage of the dried article the cooked or boiled milk taste tends to decrease in intensity.

The Bacteriological Quality of Spray Dried Milk.—One may be inclined to think that since milk has been pre-heated to 190° F. and spray dried it should be almost sterile. Milk and milk products which have been heat treated do not contain pathogenic organisms, and should not contain large numbers of non-pathogenic types. Coliform organisms are readily destroyed by pre-heating but heat resisting organisms remain and the temperature of the pre-heating determines the type and the relative number of the micro-organisms present in the powder. These non-pathogenic organisms—streptococci, micrococci and spore bearing organisms—can be effectively controlled by the same measures necessary in the care of pasteurized fresh raw milk, namely sterilization of the plant, control of the pre-heating temperature

and strict attention to the hygiene of personnel. To spray dry milk after pasteurization and sell it over the counter would settle almost all the difficulties attendant upon the supply of safe fresh liquid milk. If dried milk is to be advocated, the raw milk must be pasteurized and the dried milk must be of exceptionable bacteriological quality. Naturally dried milk must not be left exposed to the air for long periods; it should be used as soon as possible after reconstitution. To all this might be added, but with much less hope of acceptation, the suggestion, that, with dried whole milk on the market, a suitable reconstituting machine and a refrigerator should be available for all families; this would secure for all a safe and palatable liquid milk.

There are two kinds of dried milk, a full cream powder with a fat content of 26 to 27 per cent, and a half cream powder with a fat content of 16·5 per cent. National household milk, as supplied to the public at present, is machine skimmed and is retailed in steel tins, 8 oz. of the dried powder being equal to 4 pints of milk. All National Milk which is supplied for babies is whole milk roller dried. While the bulk of the spray dried skimmed National Milk is made in the U.S.A., the Ministry of Food have in this country, prepared some 5 to 6 thousand tons of spray dried whole milk for the Services (Drummond and Moran, 1945). At present the best method to preserve whole fresh milk is to pasteurize, condense and spray dry it, pack the powder in a tin in the presence of nitrogen (i.e. a gas-pack containing 1 per cent of oxygen in the free-space gas) and seal the tin hermetically. This has been done for some time on a large scale in Canada and the product can be so reconstituted that it is, to many skilled milk tasters, quite indistinguishable from ordinary fresh liquid milk (Lea, Moran and Smith, 1943).

Since milk contains more water than most foodstuffs there is a greater saving in weight by its dehydration than is the case with other foods. A fluid pint of milk, i.e. 20 oz. or 568 c.c. weighs 20·3 oz. or 575 grams; dried, it weighs 2 oz. and measures about 80 c.c.; the dried powder, if compressed into a firm block, would occupy a space of about 40 to 50 c.c. Details of the Kestner method of spray drying milk are to be found in an article by Mattick, Hiscox, Crossley, Lea, Findlay, Smith, Thomson, Kon and Egdell in the *Journal of Dairy Research*, 1945, Vol. 14, page 116.

Quickly soluble milk blocks.—Reference has been made to the results of compressing dried milk, namely, reduction in space, limiting the exclusion of oxygen and the use of packages in place of tin containers. While there are but few foods which would be generally accepted in the form of tablets or blocks, there is no doubt as to the value of food in such form. As a corollary to dehydration several foods have been made in tablet form for use in the Services. Soup cubes have been known for many years, but the most important addition to the group of block or tablet foods is that devised by de Rousset-Hall and Ingram (1945). Milk blocks were first made by compressing a mixture of milk powder, sugar and butter fat: the block so made did not reconstitute rapidly nor smoothly. To procure a block which would break up easily, would dissolve rapidly in either hot or cold water and would reconstitute perfectly, extra fat, to a total of 20 per cent. of the mixture was added in molten form to the dried milk powder. The large fat content made it possible to cast the mixture in moulds instead of compressing it by a hydraulic press. On cooling, a continuous phase of fat cemented blocks was obtained. To reconstitute rapidly and well the broken block should be stirred into boiling water. The fat finally selected to be used in cool temperate climates was refined, deodorised cocoa butter, which is colourless, tasteless, odourless and melts at 30° C. The blocks do not crumble and are quite hard. For warmer climates, fat of higher melting point must be used, e.g. refined hydrogenated palm kernel oils and mixtures of these with cocoa butter.

Blocks have also been made in which cocoa, coffee, tea, custard and milk puddings have been incorporated in the dried milk-butter fat mixtures. These blocks keep well if protected from moisture by wrapping in waxed transparent films. (de Rousset-Hall and Ingram.)

FISH

The dehydration of fish has its own problems, the chief consideration however, is one common to all drying processes, the control of bacterial and enzymic action which is responsible for the development of flavours and odours in the final product associated with an alteration in the original protein structure of the fish. During the first world war, experiments had been made in drying chopped fish in a vacuum (Falk 1919). The

rapid drying of macerated cooked fish between steam heated rollers had also been proposed, the dried product being regarded as satisfactory (Townsend 1922). The fact that dried fish products had not gained in public favour and the need for transporting the maximum amount of food in the minimum amount of space during the second world war, led to intensive research work on the problem of fish dehydration. Non-fatty fish have been dehydrated only on a laboratory scale. The dehydration of herrings has been placed on a commercial basis as a result of the work of Dr. G. Reay and his colleagues at the Torry Research Station, Aberdeen.

In selecting the raw material for their work the Torry investigators were of the opinion that lean fish more than any other kind, would yield a product relatively stable to oxidation and the fish they selected were cod, haddock and whiting which contain no more than 0·2 to 1·0 per cent of lipoids amounting to not more than 1·5 per cent in the dried fish. Plaice and lemon sole which contain up to 2·0 per cent of fat were also dehydrated. The success which attended the work on the dehydration of the non-fatty fish, led Dr. Reay to undertake the apparently much more difficult problem of dehydrating fatty fish, e.g. grey mullet with a 5 per cent fat content, and herring and salmon, with an average fat content of 15 per cent. The salmon and herring are subject to wide seasonal variations in their body fat. The highly unstable oils of the fatty fish made it improbable that they could be successfully dried in warm air. It was for this reason that the first experiments were made on lean fish.

Dehydration of Lean Fish.—Since drying in a vacuum at low temperatures was an accepted method with regard to foodstuffs other than fish, the method was accordingly given a full trial. The results were not satisfactory. The dried product did not reconstitute well on soaking, the flesh being bleached, spongy and not so glutinous as fresh fish and the taste inferior to that of fresh or frozen fish. It was clear that protein denaturation had seriously affected the reconstituting properties of the dried product. The methods now employed are, roller drying and drying in warm air.

Roller Drying.—As a result of experimental trials it was apparent that only the flesh of the fish should be used and it should be pre-cooked to prevent it sticking to the meshed trays. A small roller drying machine was set up at the Low Tem-

perature Research Station, Cambridge, in which rollers were heated, by steam under 40 lb. pressure per sq. inch, to a surface temperature of 142° C. (287·6° F.). The rollers, moving at a rate of $4\frac{1}{2}$ r.p.m., dried the fish, in a fraction of a minute, to a water content between 5 and 10 per cent. The product was in the form of a lace work of thin white porous ribbons and reconstituted very well, absorbing an amount of water comparable to the water content of the fresh raw fish. There was still some loss of the aroma of perfectly fresh fish.

Air Drying.—For the purpose of dehydrating fish in a current of heated air the semi-automatic kiln described by Hardy and Cutting (1942) for the smoke curing of fish was utilized. The kiln was readily adapted for drying, means being provided for the control of the flow, temperature and humidity of the air, as well as the rate of movement of the trays. Before being passed into the drying chamber, the fish are thoroughly washed, beheaded, skinned and filletted ; the flesh is minced, spread on trays to the depth of an inch and cooked for 30 minutes at a steam pressure of 2 lb. per sq. inch, the time and pressure of cooking being appropriate to the amount of fish. The loss of juice on cooking causes no change in the flavour of the fish when reconstituted and apparently, there is no need, as in the case of meat, to return the juices to the drying material. After cooking, the minced fish is placed on the drying trays at a density of 2 lb. per sq. foot and exposed in the drying chamber to a temperature not exceeding 70° C. The drying time is important ; the shorter the drying time the better the quality of the dried product. The practical limit is about 4 hours. The total drying time is that which is required to dry from a water content of about 2·7 grams per gram of solid to 0·1 gram per gram of solid. The dried fish contains 75 per cent of protein, is completely edible compared with the fresh fish which contains 16 per cent of protein and is about 40 per cent edible.

Dehydration of Herrings.—In normal times more herrings are caught than can be immediately consumed, and in view of the excellent results obtained in the dehydration of non-fatty fish the Ministry of Food were interested to discover whether any processes could be devised to afford additional outlets for the disposal of the great seasonal harvest of herring which is so great a feature of our coasts. If herrings, with their high content of protein and fat, could be dried and compressed in the interest

of feeding our armies in war time, there was no reason why similar action should not be taken to feed the nation in times of peace. Laboratory work has shown that this can be done. Fresh herrings are packed in ice as soon as they are landed and sent to the factory where they are washed, split, gutted and filletted and again washed in special machines capable of dealing with 2 crans of fish per hour. A cran is a capacity measure, the average equivalent weight of which is 392 lb. or $3\frac{1}{2}$ cwt. The fish are cooked for 20 minutes under a steam pressure of 6 lb. per sq. inch. They are then minced and spread on trays to a density of $2\frac{1}{4}$ lb. of mince per sq. foot tray area and passed through the Hardy and Cutting drier.

The following drying procedure is generally applicable to all fish. With air moving at 10 feet per second and trays loaded to 2 lb. per sq. foot, the dry bulb temperature is maintained for 2 hours at 85° C. (185° F.) and the relative humidity at 30 per cent (wet bulb temperature 60° C.). The dry bulb temperature is then reduced to 75° C., the relative humidity to 25 per cent and, for the final half hour, the dry bulb temperature is further reduced to 70° C. The fish is therefore kept at a temperature between 65° and 70° C. (149°–158° F.). Cod, haddock, whiting and herring, fresh or cured, have been dehydrated by this process and the final product has proved to be very good. Smoked cod, haddock and whiting have an excellent "finnan haddie" flavour and good texture; flat fish retain their flavour and also the generally crumbly texture of the fresh cooked fish. Smoked dried herrings are said to be better and more acceptable than fresh dried herrings. Dried herring because of its high percentage of fat is particularly liable to deterioration through oxidation; it is therefore essential to pack the dried fish in metallic tins and replace all air with nitrogen. In the endeavour to save space in storage and transportation, experiments on the compressibility of dried fish have shown that lean and fatty fish do not behave similarly. Dried fatty fish can readily be compressed to firm cohesive blocks but dried lean fish with a water content of 5 per cent can not be made into cohesive blocks. If the water be raised to about 10 per cent a block can be made and the texture of the fish upon reconstitution does not suffer appreciably. While no final decision has been reached on the optimal water content for storage of dried fish, it may be taken that a water content over 7 per cent on a fat free solid basis would be detrimental.

VEGETABLES

The general principles, already stated, are applicable to the dehydration of vegetables. There are naturally technical differences in the details of the methods used for drying various vegetables. The green leafy and root vegetables require to be thoroughly cleaned, waste leaves or skin removed. Preparation for drying entails shredding, stripping or dicing by machine according to the type of vegetable to be dried.

Green Leafy Vegetables.—Green leafy vegetables are either scalded by steam or immersion, for 2 to 3 minutes, in boiling water containing about 0·22 per cent of sodium sulphite. The sulphite reduces the loss of vitamin C in scalding and prevents discolouration during drying and storage. At the beginning of dehydration, which is carried out in a tunnel (Fig. 35, Group 2, Type 1), the temperature is about 95° C.; towards the end it approaches 60° C.; the wet bulb temperature is also controlled. During this time, 3 to 5 minutes, the water content falls to 5 per cent. If cabbage, for example, is dried raw, that is without previous scalding, there is a marked loss of vitamin C and considerable discolouration. Steam scalding after dipping the vegetable in sulphite has now been shown to be a satisfactory procedure (Allen, Barker and Mapson 1944). The dried cabbage must be packed in sealed tins so that it will not take up moisture from the atmosphere and if destined for long storage periods it should be packed in nitrogen. The saving of weight by drying is very marked; 100 lb. of cabbage as purchased gives about 50 lb. prepared for drying, and about $3\frac{1}{2}$ lb. of dried cabbage.

Reconstitution of dried cabbage is simple; the dried material is placed in a minimal amount of boiling water and allowed to cook at 100° C. for 20 minutes.

Potatoes.—Potatoes require very special attention on several points: vitamin C is very readily lost, the high starch content may cause pastiness, and the liability to discolour may be troublesome. The potatoes are peeled, cut into strips about $\frac{3}{16}$ inch by $\frac{1}{4}$ inch, washed in running water to remove starch which, if not removed from the surface of the strips, will cause them to stick together during drying with the production of a rather sticky paste. The loss of starch during washing amounts to about 15 per cent but in view of the large amount present is of no moment. The strips are then scalded for a few minutes

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in boiling water containing 0·05 per cent of sodium sulphite. If the amount of water is as small as possible, the loss of vitamin C will be reduced and there will be a minimal loss of mineral salts by leaching. Vitamin C is also conserved by repeatedly using the same water for scalding. Sulphite and rapid scalding are important if vitamin C losses are to be kept within reasonable bounds. The prevention of darkening of the potato has been a problem, due to lack of knowledge of the chemical processes involved. Acidifying the scalding water and avoiding contact with iron helps considerably but it is best prevented by using a non-darkening strain of potato, of which the King Edward is highly recommended. The temperature and water content are controlled as for cabbage. The dried product should be cooked by adding boiling water to cover it allowing it to stand for 1 hour and cooking until tender (5 to 10 minutes) : this will generally retain 40 to 50 per cent. of vitamin C content of the dried potato.

In sealed cans with nitrogen at 15° C. dried potato will keep for at least a year.

The saving in weight by drying is about 90 per cent ; 100 lb. of potatoes prepared by washing, peeling and slicing yield 75 lb. of strips which give a dried weight of 11 lb. Potatoes are a good source of vitamin C : they are also valuable as a source of vitamin B_1 of which 35 to 50 per cent is lost in scalding.

Mashed Potato Powder.—This is a remarkably successful product of the art of dehydration. Potatoes are cooked, mashed and then dried. The dried powder, which is granulated and consists of unbroken potato cells, can be reconstituted immediately by the addition of hot water. The drying is carried out in two stages ; first, the wet mash is dried to a consistency which permits of it being ground into a granulated powder in which the potato cells are undamaged. It is then dried on trays in a tunnel. The wet mash may be diluted and spray dried : this gives a very good powder in which no cell damage occurs. By maintaining an undamaged potato or starch cell, no starch is liberated and therefore the powder, as reconstituted, gives an excellent potato mash. Were the potato cells broken and starch liberated, the powder would on reconstitution form a paste.

Pre-cooked Dried Soups.—Many dried soups are on the market. These consist of hydrolyzed proteins, egg albumin, carbohydrate, fat, vitamins and herbs. The drying is carried out on a roller system. Vitamin C and the flavour, be it meat

or vegetable, are well conserved : the essential oils or herbs—mint and thyme oils for vegetable soup and pimento and clove oils for meat and vegetable—are added immediately after drying. The powders which are either packed in tins in a neutral gas or in water-proof packages, are easily reconstituted by stirring in hot water. The following Table gives the weights of the prepared, cleaned ingredients required to produce one ton of wet purée. (Fidler *et al.* 1945).

TABLE 48

Vegetable Soup	*lb.*	*Meat and Vegetable Soup*	*lb.*
Potato	920	Lean beef	320
Carrot	460	Potato	650
Cabbage	230	Carrot	350
Fat	$25\frac{1}{2}$	Cabbage	192
Oatmeal	44	Fat	55
Salt	$17\frac{1}{2}$	Oatmeal	43
Yeast extract	$17\frac{1}{2}$	Salt	17
Pepper	$\frac{3}{4}$	Pepper	$\frac{1}{2}$
		Yeast extract	13
		Onion	—

Carrots.—Such a rich source of carotene, the precursor of vitamin A, and of carbohydrate, came early into the field of experimental dehydration. To reduce 100 lb. of raw carrots to $7\frac{1}{2}$ lb. of dried material with but a small loss of carotene was a worth while project. Investigation soon showed that carrots dried without initial scalding, although containing practically all their carotene and sugar, would not keep well and were hard and tough when reconstituted. Scalding the carrots whole, for 15 minutes in boiling water resulted in a dried product which retained 90 per cent of the carotene of the raw vegetable and, with suitable precautions in drying, lost nothing in flavour and texture. For dehydration scalded carrots are cut into strips about a quarter of an inch square and dried to a water content of 5 per cent in a manner similar to that used for drying cabbage. To reconstitute and cook dried carrot, it is either covered with hot water, left overnight and then simmered in the same water for 20 to 40 minutes, or it is covered in boiling water, kept for an hour and cooked until it is tender. To store dried carrot successfully care must be taken to prevent oxidation of carotene. The small loss of carotene which does occur is not important, because of the large amount present, but oxidations cause " off flavours " which make the reconstituted carrot unpleasant to the palate.

It is therefore necessary to pack dried carrot in hermetically sealed tins filled with nitrogen ; dried carrots will not store satisfactorily in air ; carotene breaks down and in a few weeks a strong smell of violets may develop.

The Drying of Foodstuffs by Vacuum-Oil Technique.—This new method of drying foodstuffs in an edible oil ensures the destruction of enzymes and the retention of flavour and, to a considerable extent, of the nutritive value of the foods. The principle of the method is to subject the suitably prepared foodstuff, immersed in a non-aqueous liquid, to a temperature which will destroy enzymes without the removal of a substantial proportion of the water from the food and thereafter to secure the evaporation of the major portion of the water at a low temperature and at a pressure below atmospheric pressure. Before cooking, the oil may be removed from the foodstuff by solvents, draining or centrifuging. It is noteworthy that blanching in water or water vapour at temperatures about 100° C. is eliminated ; this prevents the loss of water soluble vitamins, small though it may be, which is occasioned by blanching and scalding. Foods which require to be blanched are kept in oil at 80° C. for 2 to 4 minutes *before* the water is removed. This treatment destroys enzymes as judged by the absence of oxidase reaction. If the food were dried immediately in oil then a temperature higher than 80° C. would be necessary to destroy enzymes. There is no loss of nutrients into the oily material such as occurs with blanching in water. The flavour and colour of green leafy vegetables, green peas and potatoes are stated to be superior to the flavour and colour of air dried products. The vacuum-oil dried products are easily and rapidly reconstituted. The time of drying, the water content and amount of ascorbic acid retained by the vacuum-oil technique are, according to Dr. B. S. Platt (1944), as follows :—

Material	Weight grams.	Drying time mins.	Water content per cent.	Ascorbic acid percentage retained
Spring greens . .	100	45	2	70
Brussels sprouts . .	78	40	4	79
Peas (green) . . .	110	75	7	55
Potato slices . .	248	60	11	66
Cabbage . . .	319	90	2	—
Beef raw (mince) . .	482	130	14	—

THE FUTURE OF DEHYDRATED FOODS

It may be safe to assume that the development of dehydration of foodstuffs will not cause any diminution in the total consumption of fresh foods. Beef produced in this country, fish caught in home waters will still in their fresh state command a market. But a great deal of meat and fish is imported and if the quality of these foods is to be retained and the cost of their importation reduced, they must necessarily be dehydrated in the countries where they are produced. Since it is possible to produce dehydrated foods of high quality, there should be no reason to doubt that the future will see a great increase in the use of certain of these foods. Reference has been made to the saving of shipping space and the dispensing with refrigerated ships by the use of dehydrated meat. The same argument holds for fish caught in the Icelandic fishing grounds. Dehydration in Iceland would dispense with large refrigerated trawlers which would still require to be built. Fish is not at its best when it has been kept on ice while the trawler has spent weeks on the fishing grounds ; it is not at its best after 5 days on ice in the hold of a trawler, the time taken for the average trawler to reach Aberdeen or Grimsby from Iceland. There are still those who regard dehydration as a menace to established industry. As far as fish is concerned " the only menace ", to quote Sir Joseph Barcroft, " that dessication could present to the trade in home caught fish would be to those dealers who allow it to deteriorate before it reaches the consumer." In other words, fresh food, from land and sea stands in no danger of a diminishing market. The public have had experience of dried milk, dried egg powder, dried soup powder. Many members of the services have, in addition, eaten reconstituted dried meat and dried vegetables. Dried meat and dried vegetables are unlikely to take the place of preserved meat and vegetables. As long as meats, tongue, pressed beef, etc. and vegetables, e.g. green peas, asparagus, carrots, etc. are preserved in their natural condition in tins or glass vessels, it would seem unlikely that the dried product could successfully compete with them. To attempt to prophesy as to the future of dehydrated foods would be foolish. The future depends upon the improvement of techniques in drying, be it meats, vegetables or fruits. The possibilities of preserving perfect taste, flavour and texture in reconstituted foods are

indeed great. There are undoubtedly certain dried foods which should come into general use, and one of these is milk. If for household use *full-cream milk of the highest quality were spray dried* and packed in neutral gas in hermetically sealed containers, it would assuredly be a most valuable food, useful not only for cooking but for the feeding of children. By the use of such a product, all the difficulties which loom so large over the sale of safe milk would be solved. Dried egg powder has not, up to the present, impressed the housewife. Non-metallic containers, and the lack of storage under nitrogen during the war, have perhaps prevented dried egg powder from being welcomed in truly domestic circles. Its value in baking, in large catering establishments and for manufacturing purposes is none the less acknowledged, but one cannot expect any artificial product to take the place of a fresh shell egg. The future of the dried egg industry lies in the realm of foreign trade.

With regard to vegetables there appears to be only one hopeful product : it is potato mash powder. Whether or not its future is assured, only the future will tell. As an energy food, it should be ideal in many ways for it will reconstitute perfectly even in cold water, and since all the water is taken up by the powder, nothing is lost by leaching out.

In this country fruit has not received the attention it deserves. Dehydration of English fruits should be carried out on a large scale, in order that, irrespective of seasons, fruit may be available in greater measure. Apples, pears, plums, blackberries, loganberries, etc. should form a rich harvest, profitable for both producer and consumer alike. It has been stated that fruit grown in Great Britain, when dried, is of better quality than the imported dried product. According to Dr. Kidd of Cambridge " dried Victoria plums, greengages, etc., after reconstitution and cooking, resemble the fresh fruits ".

PRESERVATION OF FOOD

The art of food preservation, which comes down to us from ancient times, arose out of the attempts to postpone or prevent the natural processes of deterioration and decay to which all living matter is subject. Foods change in colour and flavour when damaged or left exposed to the air ; the chief factors responsible for such change are enzymes and micro-organisms

acting in the presence of moisture and generally, as far as foods are concerned, in the presence of oxygen. The cut apple turns brown ; the sprouting grain becomes musty ; the germinating pea loses its fresh flavour, and, exposed too long to the air, meat becomes tainted. On the other hand enzymic action may exert an effect, the appraisal of which, is determined by custom or taste ; fish which has acquired an odour unbearable to the Occidental may be highly acceptable to the Oriental ; a hare, hung for a known period of time, is received with approbation by some, and eggs have a quality and flavour all their own which, in the opinion of some, ripen with age. The part played by bacteria in decomposing food is already well known ; under suitable conditions of temperature and moisture bacteria multiply rapidly, breaking down both protein and carbohydrates. When meat putrefies, toxic amines are formed ; these are responsible for the so-called ptomaine poisoning when unsound meat is eaten. One of the most interesting of micro-organisms which causes deterioration of food is the single cell yeast plant, This grows rapidly on food and in virtue of an enzyme produced by, or present in, the cell, sugars are broken down in the absence of oxygen to alcohol and carbonic acid gas ; this is alcoholic fermentation, a complex of processes which has been intensively studied by many biochemists.

The various coloured moulds on bread, jam and fruits, with which all are familiar, are made up of small white filaments at the ends of which are small coloured spores—blue, green, brown, etc. Moulds require moisture for their growth, hence the value of a refrigerator or a tightly closed tin box in preventing the growth of moulds on foods. Moulds and yeasts most generally attack fruits, vegetables, bread, cakes, moist cereals and salted meats. Milk and meat are readily attacked by bacteria, while well smoked meat and fish are resistant to yeasts, moulds and bacteria. Enzymes, yeasts, and moulds are easily destroyed by a temperature of 65° C. (150° F.), bacteria require temperatures of 70 to 80° C., and spores, which are heat resisting, require higher temperatures and longer heating than bacteria.

Salting, smoking and freezing are probably the oldest known methods of preserving food.

As to when salt was discovered and used as a preservative, there is no record, but, that tribes and armies on land and sailors upon the sea, have travelled great distances on food so

preserved is well known. Salt has always been used to preserve foods which have a high water content, e.g. meat, fish and vegetables. The commonest vegetable preserved with salt is cabbage; the preparation is well known—Sauerkraut. Many fish from many waters are salted and to-day these two foods remain the only representatives of foodstuffs preserved on an extensive scale by means of salt.

Smoking is an ancient method of preserving meat. We can well imagine the experimental method of trial and error, whereby primitive man found that hanging his surplus joint of meat in the smoky recesses of his cave, not only preserved it, but enhanced its flavour. In the more modern methods of smoking meat, advantage is taken of the penetrating qualities and odour of smoke obtained by burning different varieties of wood. For example, in Europe, birch and juniper are used; in America, maple, apple, beech and hickory; and they impart each their own characteristic flavour and taste.

Vinegar.—Another ancient preservative, although not quite so old as salting or smoking, is vinegar. Fermentation of grain was an unexplained mystery to the ancient Egyptians. In more modern times any one who possessed an apple orchard could make vinegar; the addition of a little fermented cider to the newly expressed juice being all that was necessary to convert the sugar in it to acetic acid. Cider vinegar has for long been well known in Europe and America. In the East, vinegar is made from honey and the juices of the palm: in France, or wherever there are good grapes, a fine wine vinegar is obtainable: in this country, malt vinegar is prepared from grain: in continental countries vinegar is made from rye and barley. The sour grapes mentioned in the Bible indicate another source of vinegar. Most foods can be preserved in vinegar and if the vinegar be of good quality it adds to the flavour and palatability of the food. In the past, vinegar was used to preserve fruits but to-day it is mainly used for preserving cauliflowers, onions, cucumbers, tomatoes and peppers, and as a flavouring agent.

Sugar.—Sugar is an excellent food preservative. To-day it is most commonly used for the preservation of those fruits and foods which, containing a large amount of moisture or juice, can absorb sugar. A 40 to 50 per cent solution of sugar will prevent bacterial action, and the growth of moulds. Food, if it has been preheated and if the container in which it is placed

has been carefully sealed, will keep well in such a solution for long periods.

Eggs.—The preservation of an egg depends upon the reduction, to a minimum, of its metabolic activities. The living egg slowly dies, not as a result of bacteria gaining entrance through the shell, but as a natural process of ageing. This process can be delayed by preventing the loss, through the shell, of the CO_2 produced in the egg. The U.S. Department of Agriculture have carried out experiments where the air has been sucked out of the " pores " of the shell and oil allowed to enter : the egg is thus effectively sealed. For the preservation of eggs in bulk the method is good ; for domestic, short time preservation a varnish, such as " Oteg " is very good.

Preservation by Freezing

The storage of food in ice cold boxes or rooms is a simple procedure. In winter by means of saws, picks and hoisting gear large blocks of ice are cut from the frozen rivers and lakes. These blocks are floated ashore and stored in ice-houses which, in the United States of America and Canada, are built of wood and have double walls. The principle of cold storage by means of ice is to secure a circulation of cold air : the warmer air at ground level is cooled as it rises and when sufficiently cooled falls again to the ground. Storage ice is sold in American cities and towns, the housewife thus securing, daily if necessary, ice for her ice chest. From this simple but practical method evolved the present day refrigeration plant, which commercially can freeze foodstuffs very quickly at temperatures as low as $-50°$ F. The advantage of rapid freezing is that the water within the cells is deposited as very fine crystals which do not break the cell wall. In slow freezing large crystals are formed which, by breaking the cell wall, results in a loss of juice from the food upon thawing, the foodstuff also losing some of its appearance and flavour. Certain fruits and vegetables undergo changes even when frozen fresh at 0° F. ; these changes are responsible for unpleasant flavours, loss of colour, and alteration in the structure of the food which causes juice to be lost and the food to become soft.

Freezing in syrup or sugar is effective in preventing browning during storage provided the fruit or vegetable is completely

immersed in the syrup. Raspberries, gooseberries, blackberries, red currants and bilberries can be successfully preserved by freezing in syrup. Plums and cherries, while equally well preserved, tend to discolour during thawing, even when kept under syrup until room temperature has been reached.

Scalding, before freezing in syrup, has given good results with peas and runner beans, these two vegetables being more readily damaged than most by the high temperature required for sterilisation. With fruit, scalding and freezing in syrup, does not appear to be in any measure more advantageous as regards the retention of nutritive qualities and flavour than canning. Fruit must naturally be frozen quickly enough to prevent deterioration by enzyme action. Reasonably rapid freezing of small quantities of material at $-40°$ to $-50°$ F. and storage at $0°$ to $-10°$ F. are used in the comparatively new frozen pack industry.

The Frozen Pack.—For direct consumption this method of storing raw or scalded fruit and vegetables is of interest. Fruit of the very best quality is filled into containers—tin, carton or glass—covered with syrup of 50 per cent strength and frozen quickly. Fruits like raspberries and currants, which do not turn brown or lose flavour, may be frozen without syrup, but freezing in syrup is to be preferred if fresh flavours are to be retained to the greatest degree possible: vegetables, such as peas, runner beans and asparagus lend themselves to this method of freezing. Peas, prepared by scalding in boiling water for not more than one minute, are cooled by washing in cold water, and are filled into waxed cartons. If a covering liquid is added, the peas must be cooked in it when required for consumption. If no liquid is used, precautions must be taken to prevent evaporation during storage. No alkali is used and only first class young and fresh peas are selected. Peas in the pod are practically sterile: shelled, they are open to bacterial infection which will cause discolouration; they must therefore be prepared and frozen quickly.

In November 1945 the Ministry of Food decided to grant facilities for re-establishing the quick freezing of fruits and vegetables, among the varieties to be marketed being strawberries, raspberries, gooseberries, currants, asparagus, green peas, runner beans and broad beans.

Fruit.—In the preservation of fruits to-day, they are usually

frozen in the fresh condition under syrup, or mixed with sugar. The usual method is to subject the fruit to sharp freezing at low temperatures (−30 to −40° F. are used in United States of America), and to store at about 0° F. to −10° F. Fruits *cooked* in syrup or water can be stored in the frozen state for special purposes, if desired, at moderately low temperatures—14° F. (−10° C.). If fruit is to be cooked subsequently, storage in syrup at a temperature of 10° to 15° F. is sufficient. Many fruits discolour readily and if they are to be stored for long periods the temperature must not be above 10° F. If fruits have been scalded, then storage at 15° F. is quite satisfactory. The lower the temperature, the better the product; strawberries and raspberries stored at 0° F. are always better in colour and flavour than those stored at 15° F. Quick freezing of fruits and vegetables at temperatures of −40° to −50° F. always results in a firmer texture and better appearance as, for example, with certain varieties of strawberry and with asparagus.

Vegetables.—Scalding or bleaching is necessary to avoid slow enzymic or oxidative changes which go on in raw vegetables even at low temperatures and during thawing. In the new frozen-pack method, vegetables are frozen quickly at −30° to −40° F. and stored at 0° to −10° F. If the foodstuffs have been previously scalded, vegetables, like peas, runner beans, etc., can be held in storage for periods of a year or more with little deterioration or loss of vitamin C. Very quick freezing, such as would be obtained by immersion in a liquid refrigerant such as cold brine is necessary for frozen-pack asparagus if it is not to be limp and soggy after cooking.

The rate of thawing has been stated to exercise some effect upon the quality of frozen fruits. Work at the Low Temperature Research Station, Cambridge, has not shown that slow thawing over a period of 24 hours at 34° to 40° F. is more advantageous than a more rapid thawing at higher temperatures.

Herring.—Two methods are available for preparing "quick frozen herring". The "multiplate" freezer is employed in U.S.A.; the herrings, made up in packages, are placed between plates through which liquid ammonia passes; the patent rights of this method are owned in Great Britain by Frosted Foods Ltd. The other method, the "airblast" process, has been developed and perfected largely as the result of experiments conducted at the Torry Research Station (Aberdeen). In this method,

the herrings, placed on trays, are passed slowly through a tunnel against a current of very cold air, whereby they are completely frozen within an hour. On emerging from the tunnel the frozen fish are removed from the trays by spraying the under surface of the trays with warm water ; they are then sprayed with fresh cold water and subjected to a cold blast of air which has the effect of glazing the fish and preventing evaporation. The herring are stored at $-25°$ F.

By the further development of this process the Herring Industry Board hope to provide the public with herrings all the year round. Facilities for storage of herring on a commercial scale, at the very low temperature required, are still very limited. When the operations for the production of quick frozen herring have been placed on a large commercial basis a great step forward will have been taken in the supply of a valuable foodstuff, in good condition, to all parts of the country.

Canning of Fruits and Vegetables

The first step in the canning of vegetables is to select material of the highest quality ; then to wash, cut into convenient sizes and scald or blanch. In dehydration, the loss of vitamin C was minimised by serial scalding and by the use of sodium sulphite in the scalding water. In canning vegetables this is not done, because sulphite is a great accelerator of corrosion, especially with acid products. The material is filled into the can, covered with water and the can closed with the exception of the outlet for heat exhaustion. Air is largely excluded from the can by having the head space as small as possible and sealing immediately after the heat exhaust and while the contents are hot. There is therefore little possibility of losing any vitamin C by oxidation. Canned vegetables contain as much vitamin C and soluble nutrients as similar amounts of vegetables cooked in the home (Olliver 1941).

In canning fruits it is not usual to scald or blanch them, the only exceptions being apple-slices and pears. After careful selection and necessary preparation, the fruit is placed in the can. The slight acidity due to organic acids helps to protect the vitamin C, even in the presence of oxygen. Oxygen, however, is driven out of the cans, as far as possible by correct filling and heat exhausting. This minimises corrosion, as tin is not

attacked by organic acids in the absence of air. Canned fruits should always be kept in a cool place where the temperature is as near the freezing point as possible.

Storage for Canning. Strawberries, raspberries, peas, runner beans, for canning out of season are frozen in syrup of canning strength, i.e. 50 to 55 per cent of sugar, using the same proportions of syrup and fruit as in canning. The syrup and fruit are quickly frozen to $-10°$ F. and stored at 0° to 10° F. Another method is to heat the fruit to 176° F. for 3 to 4 minutes in syrup (50 per cent), cool as rapidly as possible, freeze and store at 14° F. The pre-heating ensures that no deterioration in flavour will occur during storage. It is maintained that these fruits and vegetables are, when served, indistinguishable from those canned fresh. (Morris and Barker, 1937.)

The Canning Industry. Canning is essentially an American industry. It had its origin in France, when as a result of food shortage during the Napoleonic Wars, the government became interested in an invention by Nicholas Appert, for the preservation of food. Using glass bottles with cork stoppers, Appert cooked various foods, bottled them, recooked them by boiling the bottles in large kettles and set them aside for varying periods. As a Frenchman and a chef, Appert made up meals of such delicacies as only a Frenchman could—" eels, carp and pike garnished with veal, sweetbreads, mushrooms and anchovy butter cooked in white wine "—and subjected them to the test of preservation by boiling. His methods were good, his glass containers were not so good. An Englishman, Duran by name, produced the tin can with the required hole in the top which, after boiling, was closed by soldering. In 1817 William Underwood went from England to New Orleans to open a canning business, but failing in New Orleans to get sufficient financial support, he proceeded to Boston and there founded the first food preserving firm in America. Ere long almost every known foodstuff was experimentally canned. In the course of time, some thirty to fifty years, the canning of salmon, oysters, sardines, meat, fruits and vegetables had become an established and profitable industry. The path of progress was certainly rough in places, and one of the roughest of these was made plain by the discoveries of the greatest of all Frenchmen, Louis Pasteur. The application of bacteriological knowledge to the preservation of food was a great step forward, and by 1900 several bacteriologists were

employed by the industry in U.S.A. Engineering skill led to the development of machinery for the making of tins, the lining of metal cans with tin, the sealing of heat exhausted cans and also for gathering and preparing the foods which were to be preserved. Every foodstuff destined for the canning industry is now specially grown ; factories are established in close proximity to centres where the foodstuffs are produced. From the field to the can, the foodstuff is, in many cases, never touched by hand. Peas are gathered and shelled ; fish are cleaned and suitably cut ; pineapples are peeled and cut to required size ; and even the photo-electric cell keeps an invisible eye upon some of these processes lest anything but the best be passed for sterilisation by bleaching, scalding or final heating. To-day some of the freshest and the finest foods are in cans. The idea that inferior foods are the stock in trade of the canning industry is quite wrong. Research has shown that canned vegetables and fruits contain as much vitamin C as the fresh food. Indeed one need only examine Brussels sprouts, cabbages, cauliflowers, etc., as they lie broken and bruised in the average greengrocer's shop to realise that the destruction of vitamin C and other nutrients in such food has proceeded apace in certain parts of the vegetable, much of which has to be discarded before it is ready for cooking.

The tin can is still open to some suspicion, since it may not be entirely tinned and food may come into contact with the iron of the can. This is of little moment, particularly in cans filled with nitrogen. In cases where tin may cause discolouration of the contained food, the can is enamelled. Many people are still of the opinion that preservatives, boric acid, benzoic acid, formaldehyde or salicylic acid are used as preservatives. These chemicals did protect from spoilage but to-day they are seldom used and when used, the law demands that the fact be stated. When foods are preheated, stored in the presence of nitrogen, in air tight and hermetically sealed tins, there is no need of these preservatives. As has been shown, oxygen is the agent which must be removed if food is to be well preserved. Tin itself plays the part of a protective agent in that it tends to absorb any residual oxygen in the can.

Foodstuffs, be they dried or preserved, should be made available to all. Scientific research has made possible a great variety of palatable and nutritious foods, both in the dried and preserved state. To the housewife in her kitchen these foods in

their fresh state represent long periods of tedious preparation, if not unqualified drudgery. There is no reason why the housewife should not benefit by scientific achievement. By making full use of mechanical methods for the preparation of vegetables, not only is time and labour saved, but there is made possible a better and fuller use of valuable foods. The cost of such prepared foods will be greater than that of the raw products, but the advantages, namely, less labour, reduced cooking costs and greater variety, will far outweigh the increased expenditure.

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CHAPTER XVII

DIET AND DENTAL CARIES

One of the most outstanding defects of the people of this country, taken as a whole, is dental caries. It is one of the strongest links in the chain of events which produces malnutrition, for a deficient diet leads to bad teeth and bad teeth lead to bad digestion and assimilation of any diet. The question of the development and preservation of good teeth is one of vital importance to the nation. The cause of tooth decay has been the subject of much discussion and controversy and as yet there is no unanimity of opinion concerning it. Many questions concerning the ætiology present themselves to us. Is it due to bacteria, to fermentation in the mouth, or to a faulty diet ?

To understand the rôle of the various factors upon which the development of teeth depends, a knowledge of the structure of the teeth is necessary. The external surface of a tooth is hard enamel, composed of phosphate and carbonate of lime. Its formation is brought about by the calcification of a substance secreted from the cells (ameloblasts) of the " enamel organ ". Beneath this is a dense, bone-like substance, dentine, which forms the main part of the tooth. The dentine is made up of numerous fine tubules which radiate outwards and upwards from the pulp cavity. The tubules contain elongated processes which have their origin in odontoblasts or the superficial cells of the pulp. When the dentine is injured, these cells are stimulated to fresh activity, and form new or secondary dentine. Stretching downwards from the part where the hard enamel comes into contact with the gum and lying between the dentine and the bone is a thin layer of cement. Between the cement and the mandibular bone there is a layer of tissue called the periodontal membrane or dental periosteum. The pulp contains blood vessels, nerves and odontoblasts or dentinal cells. The relation of these various parts one to the other is shown in Fig. 36 : it is upon the vitality of all these dental tissues that the soundness of the teeth depends.

It has been shown that diet plays an important part in the development of the body and it can be shown that it plays an equally important part in the growth of the teeth, a part which is ante-natal as well as post-natal.

The Development of the Teeth.—The germ of the incisors of the *deciduous dentition*—the milk teeth—first appears in the fourteenth week of embryonic life; calcification begins about the twentieth week and is completed between the eighteenth and twenty-second months after birth. While the first signs of calcification of the *permanent teeth* are evident about the time of birth, the first appearance of the "germ" or nucleus of development of these teeth is seen at the twenty-fourth week of intra-uterine life. Between the first and the fifth years calcification of the permanent teeth begins and is completed between the eleventh and eighteenth years, with, of course, the exception of the third molars. Therefore, throughout a period extending from the sixth month of intra-uterine life to the years of adolescence, the structure of the teeth is exposed to the influence of nutritional factors.

The Fat Soluble Vitamins A and D and the Mineral Salts.—A survey of the literature on the relation of dental caries to vitamin and mineral dietary deficiencies shows definitely that dental caries is the result of many factors. Of these the best known are vitamins A and D and the salts of calcium and phosphorus. With knowledge limited to such a small number of factors, it must be admitted that dental health can best be conserved by a good diet rather than by specific vitamin or mineral therapy. It would appear from the researches of Lady Mellanby in this country, Professor Wolbach and his colleagues of Harvard University, and many others, that the activities of the nutrients referred to are specifically related to the structural elements of the teeth. That vitamin A has a definite action in maintaining the growth of the incisor teeth in rats and guineapigs is shown by the chalky or white appearance and brittle nature of the enamel of these teeth when the animals are fed on a vitamin A deficient diet. Upon the withdrawal of vitamin A from the diet, the enamel organ soon ceases to function and, with the subsequent loss of enamel, dentine is exposed; ultimately the odontoblasts suffer damage and finally atrophy.

In caries, experimentally produced by feeding animals

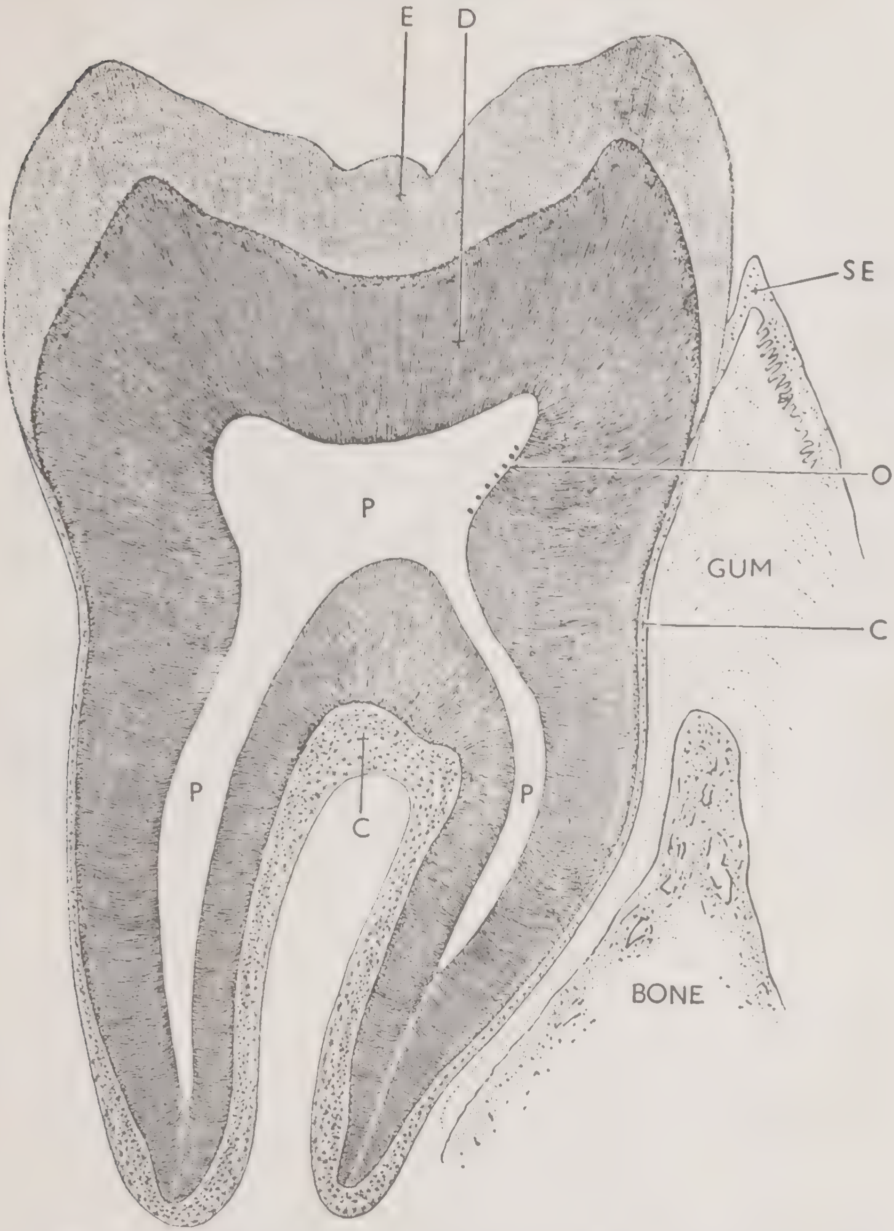
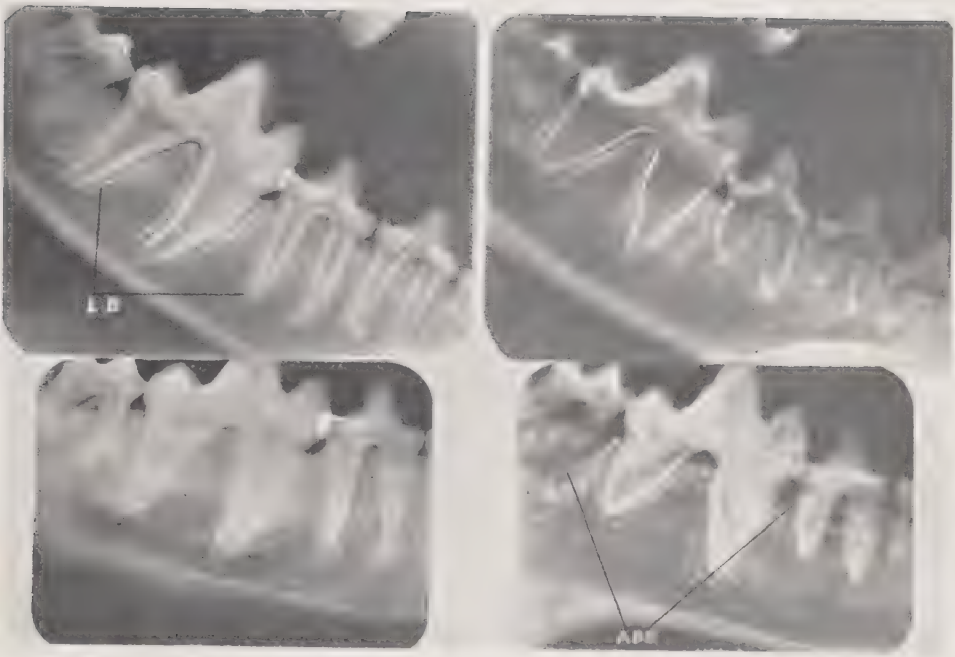


FIG. 36.—Longitudinal section of a molar tooth of a man × 8 showing the three main elements of the tooth, dentine, enamel and cement and the relation of the periodontal membrane to cement. (Partly re-drawn from Sobotta.)

E = Enamel	C = Cement.
D = Dentine.	SE = Sublingual epithelium.
P = Pulp.	O = Position of Odontoblasts.

vitamin A and D deficient diets, or by giving a diet low in calcium and lacking vitamin D, it has been noted that caries was frequently associated with the development of rickets. It is known that children will develop both caries and rickets even when their diet includes milk, and therefore is not lacking in calcium, but is almost free from vitamin D. Puppies fed on a rickets producing diet, that is a diet deficient in mineral salts and vitamin D, show thickened jaw bones, delayed eruption and irregular formation of the teeth, with a rough and grooved enamel and a poorly formed dentine. Fig. 37 from Lady Mellanby's researches on the effect of diet on the teeth, show the result of a vitamin D deficient diet as also the remarkably beneficial effect of adding fat soluble vitamins A and D. The effect of alterations in the fat soluble vitamin content of the diet upon the structure of the teeth in puppies is well shown in Fig. 38. It is possible to determine the amount of calcification taking place during known periods on different diets. The three photomicrographs in Fig. 38 are of the lower carnassial teeth of three puppies of the same family, which, at the age of six weeks, were all given, as a basal diet, oatmeal 40–100 grams, separated milk powder 20–30 grams, lean meat 10–20 grams, orange juice 3–5 c.c., yeast 3–5 grams and sodium chloride 1–4 grams. The puppy, the section of whose teeth is shown in No. 1 of the figure, was given 10 c.c. of olive oil throughout the whole experiment; the calcification of the dentine was poor; the percentage of calcium oxide in the teeth was 15·3 g. In No. 2 cod-liver oil was given during the last month of the experiment and the section shows poor calcification in the earlier part of the experiment and a marked improvement in the formation of enamel and dentine during the last month. The older dentine is globular, while the newer dentine close to the pulp has much smaller globular spaces and the amount of dentine formed in one month equals that of the previous four months; the calcium had increased, the percentage of calcium oxide being 20·4 g. The value of cod-liver oil in maintaining good development of the teeth is shown in No. 3 where a large amount of well calcified dentine has been produced in the same time as the small amount of badly calcified dentine in No. 1. The marked improvement is reflected in the amount of calcium oxide in the teeth, namely 29·4 g. per cent. The effect upon the teeth of the deficient dietary over a prescribed period

1  1

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A B

Fig. 37.—A. The influence of vitamin A and D on development on the periodontal tissues. Diet from $1\frac{1}{2}$ months for $6\frac{1}{4}$ years contained bread and a liberal supply of vitamins A and D. A1. At the age of 9 months; teeth and bones normal. A2. At age of $5\frac{1}{2}$ years; teeth and bones almost normal. B. Diet from $1\frac{1}{2}$ months for $6\frac{1}{4}$ years contained bread and little fat soluble vitamins A and D. B1. At age of 9 months; teeth and bones poorly calcified. B2. At age of $5\frac{1}{2}$ years; much absorption of alveolar bone and irregular calcification. [*From Lady Mellanby's "Diet and the Teeth, an Experimental Study", M.R.C. Special Report. By kind permission of the Controller, H.M. Stationery Office.*]

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Fig. 38.—The effect of varying the fat soluble vitamin content of the diet during the experimental period. Photomicrographs ($\times$ 40) of lower carnassials of 3 puppies of one litter. No. 1. Olive oil 10 c.c. given over a period of $22\frac{1}{2}$ weeks, calcification poor. No. 2. Olive oil and sodium acid phosphate. After $22\frac{1}{2}$ weeks cod liver oil substituted for olive oil, experiment continued for further 4 weeks. Calcification poor in earlier part, good in latter part. No. 3. Cod liver oil 10 c.c. given for $22\frac{1}{2}$ weeks. Calcification good. Note narrow compact enamel and absence of interglobular spaces in the dentine. [*From Lady Mellanby's "Diet and the Teeth. An Experimental Study," M.R.C., Special Report. By kind permission of the Controller, H.M. Stationery Office.*]

[*To face Fig. 38.*

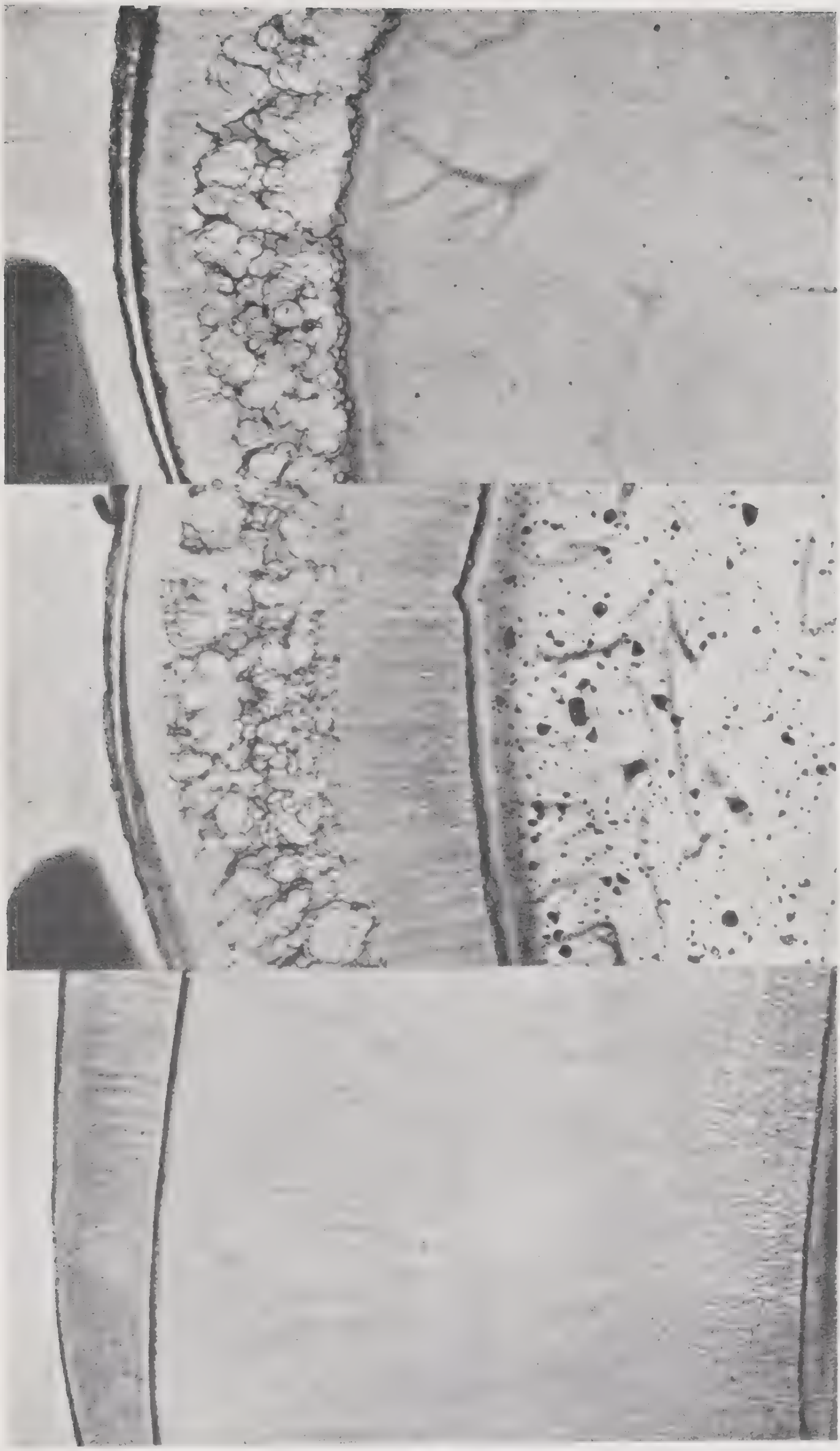

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Fig. 38.

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Fig. 39.

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is permanent. This demonstrates how possible it is, by examining a section of a tooth, to determine its dietetic history in terms of calcification. In Fig. 39 are shown the effect of salts of calcium and phosphorus added to a basal diet similar to that given in the previous experiment. The amount of calcium added to the diet of the puppy, the photograph of whose teeth is shown in Fig. 39, Nos. 2 and 4, was approximately equal to that in 125 to 250 c.c. of cow's milk, the total calcium content

FIG. 39.—The effects of salts of calcium and phosphates with varying quantities of vitamin D on the lower jaw and teeth. Puppies 6 weeks old; duration of experiment about 23 weeks. No. 1. Sodium acid phosphate 0·5–0·74 g., olive oil 10 c.c. Last month cod liver oil given. Enamel thin and badly calcified, very rough and pigmented. No. 2. Calcium phosphate 0·38–0·76 g., olive oil 10 c.c. Enamel thin, badly calcified, less rough and pigmented than No. 1. No. 3. Olive oil 10 c.c. Enamel thin and badly calcified, very rough and very pigmented. No. 4. Calcium carbonate 0·37–0·74 g., olive oil 10 c.c. Enamel fairly thick but badly calcified, rough and pigmented. Calcification shows improvement. Dentine and cement better than in the previous cases. No. 5. No extra salt. Cod liver oil 10 c.c. Note smooth white glistening enamel which is thick and well calcified. The dentine and cement are normal as is also the bone. [*From Lady Mellanby's "Diet and the Teeth, an Experimental Study", M.R.C., Special Report. By kind permission of the Controller, H.M. Stationery Office.*]

of the diets being equivalent to that in 370 to 550 c.c. of cow's milk (i.e. $\frac{2}{3}$ to 1 pint of milk). The phosphorous added was equivalent to that in 80 to 160 c.c. of milk. Taking the maximal amounts of the foods in the basal diet we find that the diet contained 10·7 grams of protein from dried skim milk powder, 3·5 grams from lean meat and 12·1 grams from oatmeal, making a total of 26·3 grams of protein of which 14·2 grams are animal protein. The calcium intake was 55 mg. from oatmeal and 367 mg. from dried milk powder (= 10·5 oz. of milk), a total of 422 mg. The protein and calcium are ample for the growth of the type of puppies used in these experiments. There is, however, an entire absence of the fat soluble vitamins A and D. The addition of calcium carbonate to the basal diet but imperfectly improved the teeth; the addition of vitamin D had a dramatic effect. These experiments also showed that increasing the amount of cereals would produce rickets in young animals whose diet was deficient in vitamin D. It was explained at that time that cereals increased the rate of growth of animals

but did not at the same time supply the necessary elements to ensure the perfect formation of the bones and teeth. While the degree of calcification of bones and teeth depends upon the relative proportion of calcium and phosphorus, protein and vitamin D in the diet, it has been shown that the cereals which contain the larger amounts of calcium and phosphorus, such as oatmeal, maize and wheat germ, caused the lowest retention of the minerals in the bones and teeth. This led Harrison and Mellanby to search for a rachitogenic or rickets producing factor. In 1939 they stated that the constituent of the cereal producing this effect was phytic acid (inositolhexaphosphoric acid), and it did so by interfering with the absorption of calcium, present either in the cereal itself or in other foods. While phytic acid is present in cereals and, although of all cereals examined, oatmeal appears to have the highest content of phytic acid (0·225 %), it must be stated that, from the point of view of practical nutrition, there is no reason to believe that the phytic acid in cereals exerts any rachitogenic effect in good diets. The phytic acid acts by binding a certain amount of calcium ; this can be offset by increasing the calcium intake, for example, by drinking more milk, or eating more vegetables. When milk is taken with porridge, one-third of a pint to 1 oz. of oatmeal as porridge, there is more than a sufficiency of available calcium to saturate the phytic acid. The rachitogenic action of cereals is only likely to become operative in diets which are on, or below, the border-line of minimum requirements of calcium and vitamin D, and unfortunately it is in these border-line diets that cereals are disproportionately high (Harrison and Mellanby).

The seasonal variations in the supply of vitamin D are well known. Not so well known perhaps is the evidence suggestive of a seasonal incidence of dental caries. In a study of the rôle of vitamin D in the control of dental caries in children, McBeath and Zucker of Columbia University, U.S.A., examining over 800 children, 6 to 14 years of age, for a period of four years, found the greatest number of new cases of caries appearing in late winter and early spring, the smallest during the summer. Given graded amounts of vitamin D, 250 to 800 I.U. daily, they were able, by the use of the highest dose of vitamin to prevent the appearance of any increase in the number of new cases of caries in the late winter and early spring months.

There is evidence also to show that sunshine and warmer climatic and living conditions are not without their effect in the prevention of dental caries.

Vitamin C.—Vitamin C, the anti-scorbutic vitamin, has also a specific function in the development of healthy teeth. The bleeding gums and progressive loosening of the teeth in scurvy are evidence of the lack of ascorbic acid in the diet. That under these conditions changes are present in the structure of the teeth was first recorded in 1916 by Jackson and Moore who described hæmorrhages in the pulp of the teeth of guinea-pigs. In 1919 Zilva and Wells corroborated this and further showed that the first signs of scurvy in monkeys were to be found in the teeth. These signs related to changes in the microscopic appearance of the odontoblasts from which the dentinal tubules develop and upon whose normal tubular structure the nutrition of the teeth depends (Bödecker, Höjer). Continued deterioration of the teeth results in damage to, or destruction of, the enamel forming cells (ameloblasts) (Fish and Harris, 1934). Vitamin C also controls the formation of the cement layer between the gum and the dentine, so important for the firm setting of the tooth in the bone. These important findings had first of all their factual bases in experiments upon rats, dogs, guinea-pigs and monkeys.

Fluorine in Dental Nutrition.—In 1930 Kempf and McKay described opaque white mottling with brown staining of the teeth in the inhabitants of a small town, Bauxite, in Arkansas, U.S.A., where all drinking water, at that time, came from deep wells. The inhabitants of the neighbouring town of Benton, who drank river water, showed no mottling of their teeth. A chemical analysis of the water in 1930 gave no hint or clue as to the cause of the disfigurement. In 1931 Smith, Lantz and Smith of Arizona University were the first to show that fluorine was the cause of mottling of the teeth. Fluorine, which occurs as a trace element in certain drinking waters, is found in rock phosphates, cryolite, a double fluoride of sodium aluminium, and in fluorspar which is used as a flux in glass etching. It is regarded as the cause of the mottling of the enamel of the teeth, characterized by opaque bands and, in some cases, brown staining. Mottled teeth may be structurally good or bad. It has generally been considered that mottled teeth are resistant to caries (Black and McKay, 1916). In

America, Armstrong and Brekhus (1938) found more fluorine in sound teeth (0·011 %) than in carious teeth (0·006 %). In Tristan da Cunha, where the inhabitants show "threshold" mottling of the teeth and are often referred to as excellent examples of non-carious teeth, the fluorine content of the drinking water is 0·2 parts per million (Sognnaes and Armstrong). The detrimental action of fluorine takes place during the development of the teeth, the permanent teeth being more affected than the temporary ones. In industry fluorine poisoning of adults affects, not the teeth, but the bones, causing osteosclerosis of the vertebræ, pelvis and ribs. In India, Col. H. Shortt, I.M.S., and his colleagues have described cases of fluorine poisoning in which, at about 30 years of age, pain in the limbs, ossification of periarticular tissues and stiffness of the spine were characteristic. The amount of fluorine in the drinking water was 3 to 4 p.p.m. In this country no such skeletal changes have been found associated with mottling of the teeth. It seems that low concentrations of fluorine favour calcification but that concentrations of fluorine over M/10,000 is detrimental to the calcification of bones and teeth. Recent work by Kemp, Murray and Wilson (1942) has shown a relationship between dental fluorosis and slight changes in the end plates of the bodies of the vertebræ in children. In U.S.A. it is considered advisable to change the drinking water when the fluorine content exceeds 1 p.p.m.; 1·6 to 3 p.p.m. being regarded as sufficient to cause definite mottling of the enamel. According to Dr. Murray of Bedford College, London, few waters in England contain more than 1 p.p.m.; the fluorine content of the river Thames is 0·10 p.p.m., the drinking water in Launton, Oxfordshire, contains 0·85 p.p.m., in Maldon, Essex, it is 5·0 p.p.m., this town being noted for mottled teeth.

Dental Surveys.—The studies of Lady Mellanby, in this country, on the relation of the surface structure of the teeth to dental caries showed that in 1500 sectioned deciduous teeth there was no caries in 78 per cent of teeth with well calcified dentine and enamel, and extensive caries in only 7·5 per cent of teeth of good structure. She also found that deciduous incisors are as a rule better calcified than deciduous molars due to the fact that incisors are almost completely calcified before birth. Incisors are less liable to decay than molars. An examination of permanent teeth in children, 6 to 14 years of

age, showed " the prevalence and degree of caries to be comparatively small in such young children since the majority of the permanent teeth have only recently erupted or are erupting. Nevertheless, the percentage of diseased teeth is seen to increase with the severity of surface defects."

One of the most revealing findings in any dental survey is the percentage of children of 7 years of age who have a decayed first molar. The first molars begin to calcify just before birth and complete their calcification between the ninth and tenth years: they erupt generally during the sixth year and are known as " the six year molars ". Upon eruption they have 3 to 4 years of further calcification before them. It has been said in U.S.A. that only about 60 per cent of children can, before their eighth birthday, display four perfectly sound first molars.

That nutritional factors have played a part in the general improvement of the teeth and of their resistance to disease is fully accepted. Confirmation of a steady, if slow, decrease in the incidence of dental caries is given in a recent publication by Lady Mellanby and Dr. Helen Coumoulos, on the improved dentition of 5-year-old London County Council school children, in which the results of dental surveys carried out in 1929 and 1943 are compared. In considering reasons for this improvement it should be remembered that for the past 25 years the Government has, through ante-natal clinics and child welfare centres, made special efforts to improve the standard of nutrition of pregnant women, nursing mothers and children. In 1934 the Milk in Schools Scheme came into operation whereby children could receive one-third of a pint of milk every school day. During the war priority schemes permitted nursing mothers, infants and young children to receive cheap milk, orange juice, cod-liver oil and eggs. These priorities, with the better distribution of essential foods, have had a beneficial effect upon the general nutrition of children. This is amply borne out by surveys of the clinical condition of the children in schools throughout the country and by the dental surveys of 1929 and 1943. In these dental surveys two points have been noted, (*a*) the structure of the teeth, and (*b*) the incidence of caries. In the former, imperfections of surface structure were classified into four categories: normal, where the surface is smooth and shiny; slightly defective; defective and very

defective ; in the latter there were also four categories, namely, no caries, slight caries, moderate caries and advanced caries. The following table (No. 49) shows the changes which have taken place.

These figures show a definite improvement in London County Council Schools over a period of 14 years ; 19 per cent of the children had perfect or nearly perfect tooth structure in 1943 as compared with 8 per cent in 1929, and 33 per cent had very defective structure of the teeth as compared with 58 per cent in 1929. In 1943, 22 per cent, in 1929, 4·7 per cent of children had caries-free teeth. The improvement is undoubted ; that it is due to a general betterment in diet rather than to war-time priorities of milk, eggs and supplements of vitamins A, D and C would appear to be true. In view of the present national food policy and of improved dental service, a repetition of such dental surveys on a large scale would be most valuable.

Many dental authorities regard dental decay as essentially a disease resulting from local conditions in the mouth and claim the specific factor to be the *bacillus lacto-acidophilus*. This

TABLE 49

A. INCIDENCE OF STRUCTURAL DEFECTS IN DECIDUOUS TEETH

(*M. Hypoplasia.*) (Mellanby and Couloumos)

Year	Number of Children	Percentages of Children showing			
		Normal	Slightly Defective	Defective	Very Defective
1929	1139	0	7·8	33·6	58·5
1943	1571	1·2	18·1	47·4	33·3

B. INCIDENCE OF DENTAL CARIES IN DECIDUOUS TEETH

Year	Number of Children	Percentages of Children showing			
		No Caries	Little Caries	Some Caries	Much Caries
1929	1293	4·7	11·7	20·8	62·8
1943	1604	22·4	25·9	22·4	29·3

cannot rule out the fact that the nutrition of the teeth is maintained by the blood and lymph in the dental pulp. It has been suggested that the dentinal cells, the odontoblasts, as part of their metabolic activity secrete lymph or a lymph-like fluid, which, passing through the extremely fine dentinal tubules, nourish both dentine and enamel (Bödecker). In infants and children the dental pulp is much more vascular than in adults; a fact which explains how readily nutritional deficiencies and diseases leave their mark on the teeth of young people. While, because of the difficulties attending large controlled dental surveys, there may be as yet little direct evidence of the effect of diet on tooth structure, there is evidence enough, indirect though it may be, that, in this country, poor tooth structure is related to dietary deficiency. Knowing the factors associated with the growth of bone and having regard to the evidence concerning the part played by the vitamins and mineral salts in the development of the teeth in puppies, we may well accept these factors as playing an equally important part in the growth of human teeth, for teeth are but bone specialized for a specific function.

The Care of the Teeth.—The evidence from animal experimentation and clinical investigation of children fed olive oil, cod-liver oil and vitamin D concentrates, sufficiently indicate what is required to reduce the incidence of dental caries in our children, namely, to care for the teeth of children from the sixth month of *intra-uterine life to the later years of adolescence.* It is not only a question of eating foods containing the essential nutrients but of eating those foods which stimulate the secretion of saliva, require to be chewed, and thus exercising the tongue and the muscles of mastication, keep a full flow of fluid over the teeth freeing them from particles of food which would otherwise lodge in the spaces and recesses between the teeth.

While milk supplies calcium and phosphorus, sound mastication of hard foods is also essential, for this maintains a good blood supply to the jaws, which are thus helped to grow to their maximum size, a very important factor in preventing caries because it prevents overcrowding of the teeth. Children who are fortunate enough to have parents who refuse to give them drugs and who rely on vegetables and fruits to control the activity of their alimentary canal will find themselves remarkably free from caries. A meal which ends with fruit, such as apples instead of sweets, presents something of value in main-

taining the health of the teeth. People who eat raw vegetables, fibrous fruits, almost never have fillings in their incisors or canines. There are many menus to be found in many excellent publications giving advice to parents on the correct feeding of children ; it is therefore unnecessary here to discuss the details of how to supply these essentials to children and adolescents. It remains only to emphasize this fact, that the growth and spacing of the first teeth are valuable indicators of the nutritional state of the permanent teeth. While irregularity or a tendency to decay of the deciduous teeth should not be regarded as a bad omen for the future health of the permanent teeth, it should be accepted as a warning to institute, in the interests of the permanent teeth, a better oral and dental hygiene, and to examine the diet with reference to its vitamin and mineral content. To whatever side of the dental controversy one may lean, be it to the carbohydrate *cum* acid one with the toothbrush in constant evidence, or the nutritional, with it emphasis on a good blood supply, carrying the necessary proteins, salts and vitamins, one would be well advised to regard the teeth as exposed to hazards both external and internal and to act accordingly.

Dental Needs and Dental Services.—The Interdepartmental Committee on Dentistry, under the chairmanship of Lord Teviot, recognizing that the bad state of dental health in the United Kingdom must have an injurious effect on the general health of the nation, has suggested in their interim report (1944) that steps should be taken to create a comprehensive dental service. No dental service can ever be regarded as satisfactory for the nation until, by adequate staffing, emergency dental work has become entirely secondary in importance to the practice of preventive dentistry. If dentistry is to make an effectual contribution to national health as an integral part of a comprehensive health service, the number of dentists will require to be greatly increased and the status of the profession definitely improved. There is no denying the need for dental care. Recruitment before and during the war just ended has shown that about 85 per cent of male recruits to the Army required dental treatment. It is recorded that of a group of 10,000 Scottish children in the five-year age group examined, only 1000 were free from dental caries. The preschool child is in the same unfortunate position. Not until dentistry is concerned with the ante-natal as well as the post-natal

care of the teeth, and is given full opportunity to meet the dental needs of pregnant women and nursing mothers can there be any hope for the future dental health of the nation. Education of mothers, at child welfare and dental health centres, and of school children in the elementary principles of nutrition, should include instruction in the nutrition and care of the teeth. Dental health education will be the more impressive if the dental service in schools and elsewhere is equal to the requirements which education will and should demand of it.

The relationship between nutrition and dental health is indubitable. That some children, upon excellent diets supplemented by cod-liver oil and nutritive salts, do not avoid caries is no argument against the part played by food ; it is but evidence that good nutrition is not entirely dependent upon diet, but demands good digestion, absorption and assimilation : and the quality of these functions, like the quality of the teeth, depends in no small measure upon hereditary influences.

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CHAPTER XVIII

THE APPRAISAL OF THE NUTRITIONAL STATE IN INDIVIDUALS AND COMMUNITIES

To appraise the nutritional state or to evaluate the condition of nourishment of individuals or communities is a task beset with difficulties. There are several methods of attempting to assess the state of nutrition of an individual or a community; the first, and most direct, is by clinical examination, the second by biochemical and physiological tests, the third by dietary surveys. The first method is of value, if a definite nutritional deficiency exists (e.g. beri-beri), the second is of value, not only in confirming or supporting a clinical estimate but in determining the presence of a potential or latent deficiency, the third, while of no importance at present in assessing a potential or latent deficiency will, in conjunction with the others, indicate some degree of correlation of disease with the lack of specific nutrients. The results of dietary surveys have been fruitful in offering definite reasons for the presence of malnutrition and deficiency disease in communities and among certain races; and, in the future, they may be of value in determining whether or not a potential deficiency exists. To do this, however, the development of the signs and symptoms of deficiency would have to be carefully observed in relation to given levels of intake of specific nutrients in various dietary patterns and in numerous communities. No community and few individuals have ever been maintained on dietaries, in which subminimal amounts of one or more nutrients were kept at pre-determined levels. Experiments in which specific additions have been made to minimal diets, for example, those of Dr. Corry Mann on boys in an industrial institute and of Sir John Orr on elementary school children, have indicated the beneficial effects of added nutrients in terms of increased growth in height and weight. It would appear that, as a practical indicator of the presence or possible appearance of under- or mal-nourishment, economic and dietetic evidence is of definite value. The recent work on vitamin synthesis would lead one to conclude that by present methods

of dietary survey no complete answer would be forthcoming concerning the *minimal* dietary requirements necessary to prevent deficiency disease in communities of human beings. The difficulty lies in the fact that it is impossible to draw a sharp distinction between the normal and abnormal in communities or individuals. In dealing with the practical problems of nutrition it is best to adhere to the clinical meaning of the word normal which has been defined by Ivy, who states that "anyone is normal who is well and not handicapped by some disturbance manifested by symptoms". This means that the mild imperfections of the body should be regarded as normal. In all its functions normal and even abnormal, the body is constantly maintaining or attempting to maintain a physiological mean. Many apparently healthy people, while not normal, are not significantly abnormal. Only when physiological adaptations definitely fail, is the significantly abnormal state entered upon, and from that, the subject may, and often does recover, without having been aware of any departure from the normal. Biomicroscopic and X-ray examinations frequently prove this statement. Just as one cannot accurately define the normal in health, so one cannot define the optimum in dietary intake. Many years ago Chittenden stated that the smallest amount of food which would serve to keep the body in a physiologically efficient state, would be, not only the most economical but the optimum, and that anything over that amount would be injurious. While nothing is gained by an excess in food intake, Chittenden's minimum left little or no margin for the ever changing needs and the many unknown adaptations of the body. The term optimum is of little practical value and in view of the difficulty of fixing a standard of perfection, the term adequate, in relation to prescribed nutrients for known conditions, seems to be the most useful. In a word, the term adequate implies the optimal, that is, the best in the supply of nutrients to meet the requirements of the individual. How difficult it is to estimate the requirements of individuals is not sufficiently appreciated. How often is it forgotten in discussing growth, that full consideration should be given not only to bones and muscle but to germ plasm. Little is known as to the specific requirements of the germ plasm in terms of nutrients. It is known that when growth is poor, the progeny become smaller and ultimately the strain dies out. That this is true of man is borne out by the appearance and disappearance

of certain races, tribes and communities. Some races are tall, healthy and long-lived; others are puny, disease-ridden and prematurely senile. Heredity does, and always will, play an important part in determining human stature and health; climate also plays a part, even if a small part, in determining physiological characteristics, and it must now be accepted that diet also plays its part, a fact which in the opinion of some outweighs both heredity and climate combined. One of the most interesting reports on the part played by diet in racial development has been referred to, namely the study of the Kikuyu and Masai tribes in Kenya carried out by Sir John Orr and Dr. Gilks. The comparative results given in that report are not confined to Kenya, they can be obtained throughout India, where various races subsisting on different diets give great opportunity for work on the numerous problems associated with nutrition and national health. The diets of Bengalis, Sikhs and Pathans vary in certain respects, and again one can see how diet must play a part in the development of physical and mental characteristics of people. Major-General Sir Robert McCarrison, I.M.S., late Director of the Pasteur Institute at Conoor, India, examined the diets of six different races, feeding series of standard rats on the various diets, the rats being kept under precisely the same conditions. The following table speaks for itself :—

Diet	*Average body weight of the group*
Sikh	235 grams
Pathan	230 ,,
Maharatta	225 ,,
Kanarese	185 ,,
Bengali	180 ,,
Madrassi	155 ,,

It is clear that there must be a radical difference between the diet of the Sikh and the Bengali or Madrassi. The Sikh diet is the most nutritious in India; it is made up of freshly-ground whole wheat (atta), which is made into chapattis (cakes of unleavened bread), milk, butter, ghee (i.e. boiled, clarified butter), curds, buttermilk, dhal (legumes), vegetables, potatoes and root vegetables, with fresh meat and water. Beef of the cow is never eaten, the animal being regarded as sacred. The Madrassi diet, the least nutritious, consists of washed, polished rice, dhal, fresh vegetables, condiments, vegetable oils, coffee

with sugar and a little milk, a little buttermilk, very little ghee, cocoa nut, betel nut and water. Sir Robert McCarrison states that rats fed on the Sikh diet live to an old age ; they suffer no infant mortality and by attention to cleanliness, comfort and food, disease has been almost completely eliminated. In fact, in many cases the rats far outlived their normal two-year span of life and had to be killed.

Infant Mortality and Malnutrition.—These experiments upon animals and the experiments performed unconsciously by various races upon themselves, show clearly how important for any race are first-class proteins, vitamins and mineral salts. The lack of these factors invariably leads to malnutrition and malnutrition is a serious handicap to anyone. That this handicap to life is due to environmental causes such as nutrition, housing, etc., is shown by comparing the death rate of infants between the end of the first and twelfth month of life and the death rate for the first year of life for various countries (see Table 50).

TABLE 50

TOTAL INFANT MORTALITY PER QUINQUENNIA : DEATHS PER 1000 LIVE BIRTHS

Quinquennium.	Scotland.	Canada.	England and Wales.	U.S.A.	Australia.	Holland.	New Zealand.
1881–85	118	—	139	—	125	181	91
1901–05	120	—	138	—	97	136	75
1921–25	92	—	76	74	58	64	43
1931–35	81	75	62	59	41	45	32
1936–40	76	64	55	51	39	37	32

TOTAL INFANT MORTALITY BETWEEN END OF FIRST MONTH AND TWELFTH MONTH : DEATHS PER 1000 LIVE BIRTHS

1901–05	—	—	—	—	—	—	44
1911–15	70	—	71	—	38	—	25
1926–30	48	48	35	29	23	32	12
1931–35	44	38	31	25	14	22	10
1936–40	39	32	26	21	12	17	10

NOTE.—New Zealand figures do not include Maoris.

The factors causing death during the first month of life are not so readily controlled as are those operating from the second to the twelfth month. The progress made in controlling the environmental factors is shown in the second part of Table 50. The death rate in the neo-natal period is due largely to factors upon which the health of the mother during pregnancy depends. Professor Dugald Baird, in discussing the influence of social and economic factors on infant mortality states that, " the most likely way to lower the neo-natal mortality rate is to lessen the incidence of prematurity ". . . . " The excess of neo-natal mortality in Scotland over that of Holland is due to prematurity and congenital debility." Similar differences in neo-natal mortality are seen when the rates for upper and lower income groups are examined. The highest mortality rates " are invariably associated with poor social and economic conditions affecting adversely the physique, health and nutrition of the mother ". It has also been shown that toxæmia of pregnancy is less common in the better nourished sections of communities. Indeed wherever we may look, be it in the East or the West, one realises that diet is undoubtedly an important factor in maintaining maternal health (Ebbs, *et al.* 1941). The neo-natal mortality rates for England and Wales and Scotland from 1938 to 1943 were :—

	1938.	1939.	1940.	1941.	1942.	1943.	1944.	1943 as percentage of 1938.
England and Wales . .	28·30	28·27	29·61	29·00	27·23	25·22	24·00	84·4
Scotland . .	35·70	36·50	37·20	39·90	35·10	32·90	32·8	91·8

Figs. 40 and 41 show how events shape themselves durin[g] periods of national difficulty. The curves show the trend o[f] neo-natal mortality and mortality in the period from the en[d] of the first to the end of the twelfth month for England an[d] Wales and Scotland and also for the four large cities of Scotland. During 1942 a record was made by Cameron and Graham o[f] the food intake of 300 women attending the Glasgow Maternit[y] Hospital, made up as follows : 100 mothers of still-born infants, 100 mothers of premature born infants, and 100 mothers o[f] full-time infants. The average daily calorie intakes in thes[e]

groups were 1644, 1710 and 1946 respectively. The diet of the mothers with full-time infants was superior in every respect, particularly in first-class protein, calcium and phosphorus. However incomplete the evidence may be of a steady improvement of the nutritional state of the nation it will be generally agreed that "the neo-natal and infant mortality rates will be most substantially improved by improvement in the standard of health and nutrition of the mothers of the lower income groups and they constitute the vast majority" (Baird). In strange

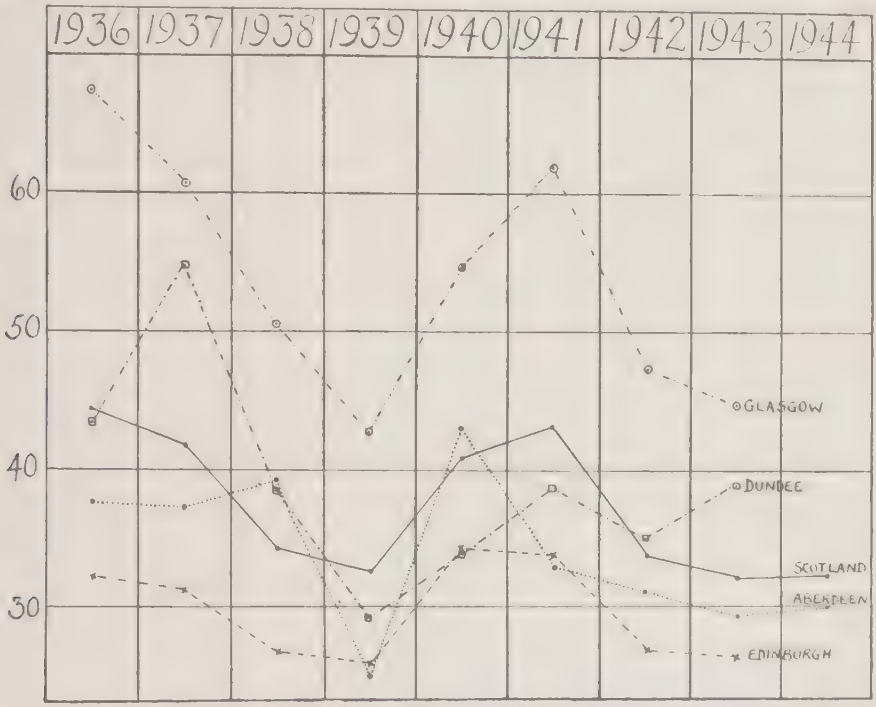

FIG. 40.—Shows the infant mortality in Scotland and the four large cities in the period 1 to 12 months. The death-rates for Glasgow, Edinburgh and Dundee, in 1944, were as follows: Glasgow, 52; Edinburgh, 23; Dundee, 32. [*Courtesy Prof. Dugald Baird.*]

contrast stand the figures in Table 50, showing the infant mortality rates for Scotland and New Zealand. That in the pre-war period, the infant mortality in Scotland should be so high, has been ascribed to "low incomes, unemployment, overcrowding and high birth rates". It may be pointed out that in New Zealand the birth rate is also high and still the achievement in reducing the infant mortality from 91 to 32 and for the period, 2nd-12th month, from 44 to 10 in a period of 40 years is astonishing, indeed it has been referred to as "one of the most remarkable achievements in the field of human welfare".

These figures should give pause to those in Scotland who are complacent concerning the social ills of her large cities and mining areas. The sum total of *all* the factors which make for malnutrition or undernutrition are to the growing child more than a handicap, they are a constant threat to life. Nothing is more calculated to take the joy out of life than malnutrition, for every function of the body, every phase of human existence is open to its onslaught. Malnutrition is not only a matter of diet, otherwise it would never be seen in the children of the upper classes. Bodily defects, sleep, exercise, economic conditions

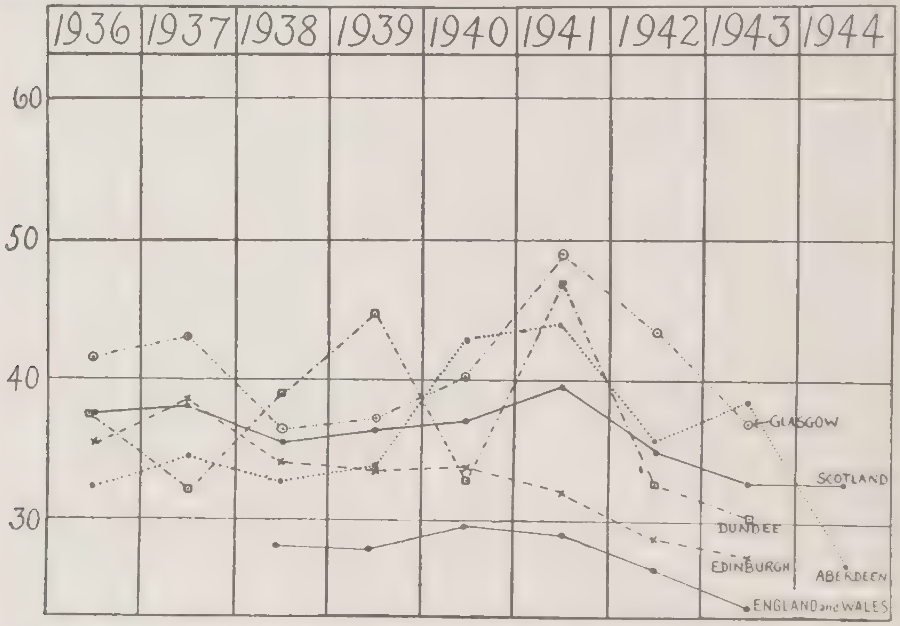

Fig. 41.—Shows the neo-natal mortality in Scotland and the four large cities from the year 1936 to 1944. The neo-natal mortality-rates for Glasgow, Edinburgh and Dundee, in 1944, were as follows: Glasgow, 43; Edinburgh, 28; Dundee, 32. [*Courtesy Prof. Dugald Baird.*]

and heredity play their part, but, as has been pointed out, they do not surpass in importance the part played by diet. Hereditary influences can be removed or modified and the hardships of environment the better withstood by communities and races if attention be paid to the correct feeding of mothers and children. The first step in combating the evils of malnutrition is the antenatal care of the child.

Signs of Under- or Malnutrition.—Malnutrition in this country is generally associated with a dietary régime of white bread, cereals and tea, to which are added potatoes and occasion-

ally minimal amounts of meat of poor quality. The deficiencies are in those foods which give first-class proteins, minerals and vitamins, namely, milk, good quality meat, eggs and vegetables. While many children are quite fat on such a diet, they are by no means healthy. Examination of their bones, teeth and muscles reveals grave defects, which sooner or later manifest themselves in disease, deformities and chronic ailments. These are the children who fill the out-patient clinics of our hospitals, for they are subject to all the minor and major ills which affect the young. Anæmic, listless and without resistance to infectious disease, these little ones are much more apt to succumb when seriously ill than those who have been fed on even very moderate amounts of milk and vegetables. While some are fat and flabby, others are thin and manifestly not fit; while some are over normal weight, others are well below it. Weight by itself should not be accepted as an indication or index of physical fitness. Any change in weight which is 10 per cent under or over the normal for the age and height, for both are important, should not be disregarded. Under-nutrition occurs readily in youth when the body is or should be growing actively. It may be produced in several ways apart from an inadequate diet. For example, digestion, absorption and utilization of the foodstuffs may be deficient; oxygenation of the blood may be reduced by reason of a poor development of the chest or by the presence of diseased tonsils and adenoids; lack of exercise in a sunless and non-hygienic environment may lead to a loss of vitality.

The Signs of Good Nutrition.—Good nutrition is always associated with a well developed body, which is not far from the average in weight and height for the age of the subject. The muscles are firm and not lacking in a fair covering of subcutaneous fat. Posture affords good evidence of the state of nutrition. A well-nourished person will stand erect; there will be no drooping shoulders nor winged shoulder blades, no flat chest nor large abdomen. The facial expression will be either calm or alert. The hair will be glossy in texture and abundant in quantity, and the appearance of the eyes bright. General health, digestive functions and the quality of sleep enjoyed will invariably be good. All this stands in marked contrast to the picture of the badly-nourished child, who is undersized, of poor physical development and whose muscles always lack that covering of fat which produces the plumpness of the well-fed

child. Posture is that of fatigue, namely, rounded shoulders, sagging head and protruding abdomen. Such children have no sparkle, they are listless, their eyes are lustreless, often sunken, and their facial expression and general restlessness are indicative of the lack of joy in life which is so often the lot of the badly fed.

A Practical Approach to the Appraisal of the State of Nutrition in School Children.—The evidence of undernutrition in this country, admittedly all too brief in its presentation here, is sufficient to call for continued and concerted action, on the part of central and local authority, in facing the problems of nutrition. The facts, however, have produced neither a yardstick nor a formula by which nutritional status could be measured. There is nevertheless sufficient in clinical, biochemical and statistical method to permit of a good approximation in its measurement. While combinations of these methods have been employed in dealing with small groups, mostly of children and adolescents, they entail so much of time and labour of teams of clinicians, scientists and nutritionists, that the results are, in certain quarters, considered not to be commensurate with the amount of work entailed. Having considered carefully ways and means of assessing the nutritional state of children, the Sub-Committee on Nutrition of the Department of Health for Scotland decided that a more practical approach to the problem, in so far as annual surveys of the health of school children were concerned, would be to investigate, by clinical and biochemical methods, *the state of well-being*, which they defined as "a general impression of the state of fitness, both physical and mental, conveyed to an experienced clinician following upon a detailed examination".

Brief reference can be made here to certain results of the latest survey of school children in Scotland, carried out by the Sub-Committee on Nutrition in 1944–45. The child population in Scotland numbers about 1¼ millions: approximately 3300 children, "entrants" (5–6 years) and "leavers" (12–13 years), from four cities and three county areas, were examined. Selection in the case of the county areas was of children from homes in which the bread winner was engaged in one or other of three occupations or industries which are characteristic of the area—heavy industry, light industry or fishing. While the sampling was guided by practical considerations rather than by the ideals of random sampling, the selection was sufficiently diffuse to present data suitable for a general comparison with past

surveys. A more extended clinical and dental survey is now being made in which about 10,000 children will be examined in 1945–46. It was found in 1944–45 that the state of well-being of *an individual* child bears no consistent relationship to the attained height or weight, and that therefore the assessment of well-being is influenced by clinical findings and not by physical measurements. This but corroborates the statement that the most direct method of assessing the state of nutrition, or better, the state of well-being, is that of a combined clinical and biochemical examination. It was, however, found that measurements of average heights and weights together, or of weights alone, are, for *groups* of children, closely correlated with the state of well-being as assessed clinically. (See Table 51).

In comparing growth rates, it was noted that boy " entrants " were taller and heavier than girl " entrants " and girl " leavers " taller and heavier than boy " leavers ". This means (see Fig. 5) that the average rate of growth in height and weight of girls exceeds that of boys about the 11th year, and that there is again a reversal in the relative growth rate at about 14½ years of age.

The most important facts in Table 51 are to be found in the last two columns. It will be noted, in comparing each of the eight groups in the 1937 and 1944 groups (underlined), that the average heights and average weights have increased. In comparing the 1934 and 1937 results there will be seen the only decrease recorded : it is a decrease in weight of girl " entrants " in 1937, of 0·60 lb. The important fact, however, is that, during the greatest war in history and during a period in which there was a more even distribution of food accompanied by increased purchasing power for the pre-war lower income groups, the boys and girls, in a fairly representative sample from Scottish schools, showed a substantial increase in both height and weight. This is a small but clear piece of evidence proving the value of the methods adopted by the Government for the supply and equitable distribution of food during the war. The data in this report would tend to indicate, among other things, that a state of well-being in children is correlated with efficiency of the mother, participation in organized games and membership of youth organizations. When, to a detailed clinical examination are added improved tests for the measurement of ascorbic acid in the white cell-platelets ; the disappearance of blood pyruvate

TABLE 51

AVERAGE AGE, HEIGHT AND WEIGHT OF CHILDREN EXAMINED BY THE EDUCATIONAL HEALTH SERVICES OF THE CORPORATION OF GLASGOW 1934–35, ROWETT RESEARCH INSTITUTE AND CARNEGIE TRUST 1937 AND THE NUTRITION SUB-COMMITTEE OF THE DEPARTMENT OF HEALTH FOR SCOTLAND 1944–1945

Category.	Time.	Average Age yrs.	Average Age mns.	Average Height ins.	Average Weight lb.	Average Height adjusted to $5\frac{1}{2}$ yrs. and $13\frac{1}{2}$ yrs.	Average Weight adjusted to $5\frac{1}{2}$ yrs. and $13\frac{1}{2}$ yrs.
				ENTRANTS			
Boys	1934	5	3·97	41·43	39·73	41·71	40·46
,,	1937	5	6·0	43·11	41·25	43·11	41·25
,,	1944	5	6·90	43·32	41·89	43·19	41·56
Girls	1934	5	4·22	41·12	38·14	41·42	38·71
,,	1937	5	8·00	41·73	38·17	41·70	38·11
,,	1944	5	6.94	42·82	40·44	42·66	40·14
				LEAVERS			
Boys	1934	13	5·39	57·01	82·07	57·11	82·58
,,	1937	13	6·00	57·68	86·60	57·68	86·60
,,	1944	13	7·18	59·22	89·45	59·03	88·46
Girls	1934	13	5·48	57·69	85·88	57·76	86·29
,,	1937	13	5·00	58·66	88·10	58·79	88·88
,,	1944	13	7·10	59·74	94·20	59·60	93·34

following exercise, as a measure of vitamin B_1 deficiency; the fasting urinary excretion of vitamin B_1, riboflavin, nicotinic acid, etc., then a general impression of well-being will the more readily be translated into an approximately accurate estimate of nutritional status.

From the results of the many dietary, budgetary and clinical surveys carried out since 1934, it will be admitted that progress, slow though it be in many respects, is being made. The experiments in national feeding have been a fruitful experience and the significance of the results attained and the methods used must be a constant inspiration to greater achievement.

Related Causes of Under-nutrition.—One must not be blind to related causes of under- or malnutrition. A sufficiency in the fulfilment of dietary needs may be futile or productive of

but poor results if hygiene be not instituted, discipline maintained and ignorance dispelled. Poverty, while a veritable cause of malnutrition, may not always be the chief factor. In many homes where essential foods, milk, fruits, meat and vegetables, are not lacking, but where parental discipline is entirely lacking, are to be found children who are under weight, thin, anæmic and without vigour. They are essentially cases of under-nutrition. Children of the upper social classes who are left to express themselves as their temperamental minds may dictate, and are allowed to select foods as rich as they are lacking in vitamins or body-building proteins, may often show signs of under-nutrition. Parental control must be exercised in matters of diet just as in matters of education. The wilful child who refuses to drink milk or dallies at meals so that it lacks nutriment in the midst of plenty, can be disciplined to regularity and alacrity in eating, if parents will but take the trouble, and it may be considerable trouble, to maintain a dietary discipline. While on the matter of parental control, it may be pertinent to emphasize the importance of over-fatigue as a cause of defective body building. Prolonged stimulation of a boy or girl to work much longer than usual in order that he or she may attain a certain position in school is entirely wrong. Many a boy with a mental capacity of 60 per cent of the normal is urged to extra work with the suggestion that he is bound for the top of his class, or sure of a certain prize, if he but works hard. When a boy of 60 per cent capacity is pushed to emulate those of 80 or 100 per cent, he is being most unfairly handled. While temporary success may crown his efforts, it is almost certain that he will ultimately realize his limitations. If he does so and sets the pace accordingly, no harm may be done. If, however, he or those who guide him do not, then physical and mental breakdown may follow rapidly upon the heels of such an endeavour strain, and if this be associated with poor feeding, the malnutrition will complicate matters and prevent a rapid return to normal.

The Treatment and Prevention of Under-nutrition in Children.—With regard to the dietetic treatment of malnutrition, it has been pointed out that diet must be the first consideration. To build up the body, it is necessary to supply those foods which will increase the size of muscle, the growth of strong bone and the resistance of the body to infection. This entails

a diet of high calorific value, containing first-class proteins and a rich supply of vitamins, the mineral salts, calcium, phosphorus and iron and many other things of which we know little or nothing. This means that the diet must consist of sugars, cereals, fats, meat, milk, eggs, vegetables and fruit. The diet *as purchased* should generally provide energy 20 per cent in excess of the needs of the normal for the age, weight and height of the subject. The degree to which any diet will fulfil the physiological needs of the body, will depend upon the capacity of the individual to digest, absorb and assimilate the required nutrients. It is important that digestive disturbances be avoided, and for this reason it is better to give three good meals per day and not to endanger appetite by eating between meals. To state that butter, cream, bacon, eggs and fruit should be given liberally was, in pre-war days, a counsel of perfection. When poverty is the chief obstacle to correct diet, it is indeed a difficult problem that faces many parents, a problem affecting not only children but adolescents.

While a greater variety of foods will be available in the immediate post-war years, the basis of all diets should be milk. Fortunately the easily digested foods are among the best, namely, milk, eggs, butter, cream, whole grains, good quality meat and fruits, but unfortunately they are still (Dec. 1945) in very limited supply. Useful adjuvants are cod-liver oil or concentrated preparations of vitamins A and C. Special arrangements have been made by the Department of Health for Scotland and the Ministry of Food for the supply of these vitamin supplements to children and expectant and nursing mothers. Cod-liver oil and fruit juices have been supplied since December 1941, the A. and D. tablets since April 1943. Despite special publicity campaigns and much propaganda by the Ministry of Food, the demand for these supplements in Scotland is materially below the national average. Figures are given in Table 52, showing the actual take up of these supplements, the estimated potential and the actual as a percentage of the potential from 1942 to 1945 inclusive.

These figures show that the results of the scheme have been disappointing, and that in Scotland the scheme is not very popular. It is cause for astonishment that in Scotland, with its short summer and long winter, there should not be a greater demand for those supplements which so thoroughly make good

the lack of sunshine, fruit and vegetables. Vitamins play a definite role in promoting growth, increasing vitality, in preventing infections and generally in maintaining an optimal state of health.

Table 52

VITAMIN SUPPLEMENTS

Actual Average Weekly issue compared with estimated potential demand. From the Ministry of Food, Statistics and Intelligence Division

1. Fruit Juices. In thousand bottles

Date	England and Wales			Scotland			Great Britain		
	Actual	Estimated Potential	Actual as % of Potential	Actual	Estimated Potential	Actual as % of Potential	Actual	Estimated Potential	Actual as % of Potential
Oct. 1942	170·6(*a*)	(*c*)	(*c*)	19·7	(*c*)	(*c*)	190·3	(*c*)	(*c*)
1943	822·9	1713 3	48·0	90·6	242·4	37·4	913·5	1955·7	46·7
1944	841·1	1734·7	48·5	107·3	241·4	44·4	948·4	1976·1	48·0
1945	713·2(*b*)	1767·2	40·4	78·9(*b*)	233·1	33·9	792·1(*b*)	2000·3	39·6

Classes eligible and entitlement

In bottles per week

Date	Children					Expectant Mothers
	Under six months	Over six months				
		Under 2 years	Under 3 years	Under 5 years	Over 5 years holding R.B.2	
1st April, 1942 .	$\frac{1}{4}$ bottle	$\frac{1}{2}$ bottle	—	—	—	—
6th July, 1942 .	$\frac{1}{4}$ bottle	—	$\frac{1}{2}$ bottle	—	—	—
1st Dec., 1942 .	$\frac{1}{4}$ bottle	—	—	$\frac{1}{2}$ bottle	—	$\frac{7}{9}$ bottle
7th Feb., 1943 .	$\frac{1}{4}$ bottle	—	—	—	$\frac{1}{2}$ bottle	$\frac{7}{9}$ bottle

(*a*) Blackcurrant syrup and puree converted into equivalent bottles of orange juice.

(*b*) Owing to shortage of supplies the rate of release to beneficiaries restricted to one bottle per ration book.

(*c*) No reliable estimate of potential is available, except for the United Kingdom as a whole, for which actual as % of potential was 21·1.

TABLE 52—*continued*

2. COD LIVER OIL

In thousand bottles

Date	England and Wales			Scotland			Great Britain		
	Actual	Estimated Potential (*a*)	Actual as % of Potential	Actual	Estimated Potential (*a*)	Actual as % of Potential	Actual	Estimated Potential (*a*)	Actual as % of Potential
Oct.									
1942	66·5	(*b*)	(*b*)	6·5	(*b*)	(*b*)	73·0	(*b*)	(*b*)
1943	127·6	510·0	25·0	14·2	71·2	20·2	142·0	581·2	24·4
1944	126·0	511·7	24·6	14·8	71·2	20·8	140·8	582·9	24·2
1945	112·2	522·7	21·9	12·3	69·3	17·8	124·5	592·0	21·4

(*a*) On the assumption that from the 18th April, 1943, no expectant mothers take cod liver oil instead of A. & D. tablets.

(*b*) No reliable estimate of potential is available, except for the United Kingdom as a whole, for which actual as % of potential was 13·9.

Classes eligible and entitlement

In bottles per week

Date	Children			Expectant Mothers
	Under six months	Over six months		
		Under 5 years	Over 5 years holding RB.2	
1st April, 1942 . . .	$\frac{1}{12}$ bottle	$\frac{1}{6}$ bottle	—	—
1st Dec., 1942 . . .	$\frac{1}{12}$ bottle	$\frac{1}{6}$ bottle	—	$\frac{1}{5}$ bottle
7th Feb., 1943 . . .	$\frac{1}{12}$ bottle	—	$\frac{1}{6}$ bottle	$\frac{1}{3}$ bottle
19th May, 1943 . .	$\frac{1}{6}$ bottle	—	$\frac{1}{6}$ bottle	$\frac{1}{6}$ bottle

3. A. & D. TABLETS

In thousand packets

Date	England and Wales			Scotland			Great Britain		
	Actual	Estimated Potential (*a*)	Actual as % of Potential	Actual	Estimated Potential (*a*)	Actual as % of Potential	Actual	Estimated Potential (*a*)	Actual as % of Potential
Oct.									
1943	23·7	(*b*)	(*b*)	2·0	(*b*)	(*b*)	25·7	(*b*)	(*b*)
1944	22·8	59·1	38·6	2·3	8·2	27·4	25·1	67·3	37·2
1945	22·6	59·4	38·0	2·1	7·6	27·6	24·7	67·0	36·9

TABLE 51—*continued*

	Eligible Class and entitlement	
From 1st April, 1943	Expectant Mothers	One packet containing 45 capsules represents 6 weeks' supply

(*a*) On the assumption that all expectant mothers take their full allowance for 6 months prior to confinement, and without taking account of purchases by any mothers earlier than 6 months prior to confinement, or of purchase in advance or in arrears.

(*b*) No reliable estimate of potential is available, except for the United Kingdom as a whole, for which actual as percentage of potential was 37·8.

In war, just as in peace, we have not been able to secure an adequate supply of antiscorbutic foods for the whole population, and we are forced to the conclusion that practical considerations make it inevitable that infants should be given the most effective vitamin C concentrate available, namely, orange juice. No person responsible for the well-being of children should fail to realize the value of milk, cheese, butter and vitaminized margarine and, in view of their scarcity, should neglect to make full use of all supplements for the prevention of deficiencies.

The Value of School Meals in the Nutrition of Children.—Few attempts have been made to relate the physical condition of school children to the nutrient content of their diet. A recent survey in Edinburgh of the individual dietary intake of middle class school children divided into two groups, namely, those taking and those not taking mid-day meals at school, showed, from mean consumption figures that, while a number of children did not receive their full share of rationed foods, the ration was not being unduly diverted to adults. It was further shown that children, who received meals at school, had at home an *average intake* of rationed food, which was less than that of the children having no meals at school, and the *proportion of children* receiving less than their allowance of rationed foods at home was greater in the group taking mid-day meals in school. "School dinner" children invariably received less of calories, protein, iron and ascorbic acid at home than the non-school dinner children, but, if the nutrients of the school meal are added to the home meal intake, then the total intake, with the exception of ascorbic acid, was slightly greater than that of the children not taking meals at school. Consciously or unconsciously the meals in school became a substitute for, and not a supplement to, the meals at home. This nullifies the value

of meals in school. So great are the energy and protein requirements of children (see Figs. 5, 6 and 7) that, at home, they should be given their correct share of all rationed foods; it should be impressed upon parents that school meals are supplementary and all children, as the new educational scheme develops, should be encouraged to take meals in school. And, it is important that education authorities should ensure that the school meal is well cooked, served hot, and supplies approximately; 1000 calories, 25 g. animal protein, 500 mg. calcium, 6 mg. iron, 30 mg. ascorbic acid (see meals, I*a* and II*a* p. 227.)

In the lean years that lie ahead the Milk in Schools Scheme and the mid-day meals in school have still an important part to play in building up strong and robust children. The Ministry of Education has based its 1946 estimates on the assumption that 75 per cent of the school population would obtain mid-day meals at school. Here is a magnificent field for the education of children in the elementary principles of healthful living, which includes, not only a knowledge of food values but of new ideas in social customs. Not only must the scheme be, as Lord Horder stated at its inception, " physiologically profitable " but " psychologically attractive ". To do this entails the appointment of fully qualified and experienced dietitians, skilled cooks and, within the framework of the scheme, the selection of teachers who would train older scholars to take an active part, and share responsibility, in making a success of school meals.

It is not intended to suggest that an adequate food supply is all that is necessary to improve health when physical and environmental defects are left unattended. All these factors which have been mentioned are inter-dependent. Food supply is the corner stone, but the corner stone is not the building.

Enough has been said to show that there is a definite relation between food and nutrition. We see it in races, individuals and animals. We have seen the old arguments for heredity and environment modified in most striking ways. It is a well-known saying that the Japanese are small because their parents are small. That is the argument advanced to explain the size of Shetland ponies. But is it so? Look at the Japanese who have been born and bred in California, and also at the children of the third and fourth generation. From generation to generation they are growing bigger and heavier. And so it is with the Shetland ponies transported to the rich pastures of the Middle

West of the United States. Away from their scanty moorland pastures, they grow larger with each succeeding generation. In Great Britain the story is the same. Boys and girls are certainly not growing smaller. The increased growth in our children is certainly largely due to improvement in modern diets. Children to-day get more milk, more vegetables and cod-liver oil in infancy than a decade ago. And fruit and more milk will be available as post-war production increases. All children in the higher income groups in Britain, Scandinavian countries, North America, Australia, etc., whose diet is rich in mineral salts, vitamins, and animal proteins, are, on the average, tall and healthy.

So it is with the Sikhs, the Arabs and the Bedouin. An adequate diet, frugal living, sunshine and constant movement are invariably associated with strength and stamina. "Wherever there are dairy animals in abundant proportion to the population and their products form the staple articles of diet, fine physical development is seen without exception" (McCollum). The pastoral Arabs, noted for their physique, live on milk from goats and sheep, meat, cereals and dates. The milk is always soured to preserve it, and is eaten as curds. Without milk they would not survive in the physical condition in which we find them to-day. Tall, thin, alert, robust and virile, the pastoral Arab is in many cases almost a perfect specimen of humanity. Simple, abstemious, living to a ripe old age, proud and often hungry, these wandering people are an object lesson in nutrition. So it is with the pastoral peoples of India, living largely on a diet of milk, butter, ghee, fruits and vegetables, they are vastly superior in physique to most of the other classes of Indians. A similar story can be told of the people of Skye, Lewis and other Hebridean Islands, who subsist on cods' livers, fish, turnips, potatoes, oatmeal and milk. Any departure from these simple but adequate foodstuffs which allows the inclusion of rich carbohydrate foods, highly-prepared cereals, tea and cakes, leads ultimately to a deterioration in the structure and strength of bones, teeth and muscle.

A few generations ago civilization seemed to be contributing nothing to the physical well-being of the working classes. The present generation has witnessed a great change. Modern methods in agriculture, transportation and scientific research all over the world have opened up for us rich and extremely

varied sources of food supply. This generation has seen the newer knowledge of nutrition put into practice both in peace and war. In this country, the old dietary of white bread, tea, sugar, meat and potatoes can be intelligently corrected, first, by creating a better balance between the energy-producing and animal protein foods; secondly, by an increase in the consumption of fruit and vegetables; and thirdly, by a greater use of milk and bread made from 85 per cent extraction flour. To-day, had it not been for the devastation wrought by insensate war, the dietary deficiency diseases of two generations ago would ere long have been eliminated from the great mass of the populations of the western world. In this country and on the continent of Europe the tragic results of a villainous experiment in world domination are everywhere apparent. In the sphere of nutrition, despite the threat of famine in cities and towns, much can be done to save children and adolescents from the effects of gross dietary deficiencies. There is no reason why the classic experience gained in Vienna in 1921 should not save Vienna in 1946; and to-day Vienna is Europe. There is no lack of knowledge as to what to do and how to do it. What is required is promptness, determination and co-ordination in action. If famine is to be averted in certain parts of Europe, it will require the strenuous efforts of all responsible national elements represented on the European Allied Council. The greatest experiment in the treatment of malnutrition is unfolding itself now and the record of the results of the work of the various Nutrition Sections of the Allied Commission in Europe to-day, will, without doubt, be of great value for future action in the field of world nutrition.

Much still remains to be done if we are to see ourselves a strong and virile nation. If nutrition be the keystone, and well it may be, of the great arch of national fitness and prosperity, attention must nevertheless be given to those other stones without which the structure could not be raised. Amongst the many important things which do require consideration in the performance of this great task, one would emphasize maternal welfare with practical instruction in the care and upbringing of children, instruction in the principles of personal hygiene and public health, a greater utilization of the land with increased employment for the purpose of a greater production of dairy products, vegetables and fruit, and lastly, and it is a point worthy of some attention, the maintenance of a well ordered political life.

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CHAPTER XIX

THE FOOD AND AGRICULTURE WORLD ORGANIZATION

By long and, at times, bitter experience we have begun to learn what better nutrition can do for the improvement of the health of individuals, communities and nations. The physiological requirements of man and the means of supplying them are known. In a broad measure we are aware of the missing factors in numerous dietary diseases; we are not without knowledge concerning the patterns of diet which the individual requires in order to maintain health and vigour of body; and we know the nature of the diets which lead to bodily impairment, ill-health, disease and death.

To look at the nutritional condition of people throughout the world is to realize how hopelessly unbalanced is the world's nutrition balance sheet. The problem of world malnutrition was briefly detailed in Chapter III, where it has been shown that many people get only enough food to meet the minimum energy needs of the human body at rest, and few obtain the amounts of proteins, vitamins and minerals necessary to build strong and virile bodies; in other chapters reference has been made to the incidence of beri-beri, pellagra, rickets, anæmia, endemic dropsy, goitre, etc. So great is the mass of evidence of malnutrition in the world that often only brief and topical reference is made in support of the facts. In a Report by the United Nations Interim Commission on Food and Agriculture (1944) significant reference was made to the "quantity and quality of life". It was pointed out that "among the diverse interests of race, class and colour, all men and women are united in their desire to live and to be healthy", and therefore the quantity of life that an individual can enjoy is of basic importance, not only to him but to the community in which he lives. The quantity coupled with quality of life is the principal component of the standard of living. National and international vital statistics, incomplete though they are, leave no doubt as to the quantity and quality of life enjoyed by the various races and nations of the world.

Expectation of Life.—A baby born in England in 1870 could expect to live 41 years ; in 1937 a baby could expect to live for 62 years ; in 67 years, 21 years had been added to the period of expectation of life, almost equivalent to the addition of a generation to the population of England. In India in 1931, life expectancy for males was 26·9 years ; in New Zealand in 1934–38, it was 65·5 years. Infant mortality in India is high, 170 per 1000 live births (1931–35) ; in New Zealand for the European population in the quinquennium 1939–40, it was 32 per 1000 live births. If in India a male child can continue to live but the first year of its life, its expectancy of life rises almost 50 per cent, namely, to 34·6 years. In New Zealand after one year, expectancy is 66·9 years, a very small increase. Similar figures obtain for Holland, Denmark, Australia, etc. ; they clearly show that among the poorer classes and in poverty stricken countries, the quantity and the quality of life is so low that one is not surprised that in certain lands a wistful desire to hold on to life is coupled with mysticism, idolatry and a hope for final relief from suffering in annihilation. To escape from " the vain world and careworn crowd, to watch, serene, the toilers in the plain " epitomizes the Buddhist saint's ideal of freedom from want and care ; it nevertheless expresses the desire of the common man for a finer quality of life which, as a result of the gradual progress of science and technology, has been brought into the realm of possibility.

The Hot Spring's Conference.—To attain to some degree of unity in the application of scientific and technical knowledge to the greater benefit of mankind, the late President Roosevelt expressed the idea that it would be of inestimable value if the United Nations could get together on some positive task. It was early conceded that the task on which the greatest possible unanimity of opinion and purpose could be expected would centre around the problem of feeding the nations. The problem is essentially one of increased production, consumption and distribution of food. The first United Nations Conference on Food and Agriculture was held at Hot Springs, Virginia, U.S.A., from the 18th May to the 3rd June 1943. Representatives of all the United Nations, 44 in number, with an observer from Denmark, representing 75 per cent of the total population of the world, met together to discuss plans for the production, distribution, transport and consumption of food all over the

world. The delegates at this Conference had the great advantage of having with them a body of experts on all aspects, scientific, economical and political, of the nutrition problem. It was therefore an easy matter for the members to be clear and authoritative in defining the problem and the measures for its solution. Meeting in the midst of the greatest war in history, they declared that " the goal of freedom from want of food, suitable and adequate for the health and strength of all people can be achieved ". During the period of actual shortage after the war, freedom from hunger can be achieved only by urgent and concerted efforts to economize consumption, to increase supplies and distribute them to the best advantage. " There has never been enough food for the health of all people. This is justified neither by ignorance nor by the harshness of nature. Production of food must be greatly expanded ; we now have the knowledge of the means by which this can be done. It requires imagination and firm will on the part of each government and people to make use of that knowledge." Such a declaration of unanimous opinion was not that of a body feeling its way, but that of one with a clarity of vision unequalled in the deliberations of many political councils to-day. There was no call to tread lightly over controversial difficulties, there was no attempt, no desire, to spend time in argument on truths self evident in the field of nutrition. That the first cause of hunger and malnutrition is poverty is axiomatic, that " it is useless to produce more food unless men and nations provide the markets to absorb it ", is none the less axiomatic, but while the former is accepted almost in the light of a piece of gratuitous information, the latter is still received with some doubt and hesitation, for it implies a new outlook on the world's economic and social systems.

The Conference recommended the early formation of an Interim and later a Permanent Commission to carry out the recommendations of the United Nations Conference. It was enjoined that all nations represented should collaborate in raising the standards of living and the level of nutrition of their peoples. The call was for immediate action with all due regard to the exigencies of war. In the words of Dr. Evang, the Norwegian delegate, " the Hot Springs Conference had created a sort of world conscience in regard to the food supply of the world ".

In dealing with dietary standards and the planning of food

supplies, the Conference, aware of the wide variations in human dietary habits, emphasized the importance of translating allowances of nutrients into terms of foods in common use, of estimating the amount of foods necessary to bring dietaries up to prescribed standards, and of making use of the data so obtained to guide agricultural and economic policies in improving the diet and health of populations.

Important amongst the many recommendations of the Hot Springs Conference was that referring to the improvement of the diets of vulnerable groups. These groups—mothers, infants and children—are the most important in any nation, and the most practical way of improving the nutritional state of a nation is for public authority to make it possible, either by adequate basic income or by bringing needed food free or at low cost to the vulnerable groups, for all pregnant women, nursing mothers, infants and children to receive a diet which meets their physiological requirements. In this connection they recommended that carefully planned mid-day meals in school should provide one-third of the daily food needs of the school child.

The Conference reviewed the information submitted by the several delegates on consumption deficiencies and the relation of food to health and " were deeply impressed by the dominant rôle played by adequate food in the reduction of sickness and death rates and the maintenance of health ". They declared it to be their opinion that " the first essential of a decent standard of living is the provision to all men of these primary necessities which are required to promote freedom from disease and for the attainment of health ; the most fundamental of these necessities is adequate food which should be placed within the reach of all men in all lands within the shortest possible time, and that ample evidence has been presented revealing the existence of malnutrition in every country with its inevitable consequences of preventable ill-health " ; and they recommended that the governments and authorities represented should take steps immediately to increase food resources and improve the diets of their peoples in accordance with the known principles of nutrition.

The wide range of the discussions has merely been indicated. Of some thirty declarations with recommendations, No. XV, in which the basis and recommendations of a Long Term Production Policy were set out, is characteristic of the vision and clarity

with which the subject-matter of most of the sections was treated. The Conference recommended :—

1. (*a*) That the inherent natural and economic advantages of any area should determine the farming systems adopted and the commodities produced in that area :

(*b*) That farming systems should be so designed as ;

(i) To maintain soil fertility ;

(ii) To protect crops and livestock from pests and disease ;

(iii) To favour steady employment throughout the year ;

(*c*) That production of nutritionally desirable foods which can be obtained only with difficulty elsewhere or not at all is a special obligation of the agriculture of every country ;

(*d*) In every region subject to drought suitable measures should be undertaken for storage, production and development of water resources and cultural practices ;

(*e*) Land used or likely to be required for agriculture should be protected from erosion ;

(*f*) The spread of existing knowledge by education and the development of new knowledge by research should be constantly promoted.

2. That with the object of expanding food production each nation should undertake to direct its policies toward :

(*a*) Increasing the efficiency of production in present producing areas through the introduction of better farming methods, suitable modern equipment, improved varieties of crops and strains of livestock, and soil conservation practices ;

(*b*) Developing any suitable undeveloped areas ;

(*c*) Fostering desirable changes in the pattern of production, designed to give greater emphasis to foods rich in vitamins, minerals and proteins ;

(i) By encouraging the production, particularly in areas near consumption centres, of such products as vegetables, fruits, milk, eggs, and meat, which are relatively perishable and high in value, and which are also the foods required in greatly increased quantities for better nutrition ;

(ii) By encouraging the expansion of livestock production in areas capable of growing or economically shipping in the necessary feedstuffs ;

(iii) By limiting the production of bulky, easily stored and transported energy foods in areas where they cannot be produced efficiently ;

(iv) By encouraging the production in single-crop areas of a greater diversity of foods for home use ;

(v) By likewise encouraging more diversified and adequate home food production in all farming areas, so that rural people may have more and better food, while eliminating the margin between producer and consumer.

3. That each country should adopt the following measures :

(*a*) The framing of policies designed to encourage production within the country of commodities that need to be produced there in greater amounts, and limit production of those that should not be produced within the country, or should be produced in smaller amounts ;

(*b*) The supplying of low-cost credit or other aids that would help producers to acquire necessary materials, equipment, and machinery for more efficient production and better use of the land ;

(*c*) The furnishing of technical assistance to producers ;

(*d*) The development of a programme of education to help producers understand better farming methods and put them into practice ;

(*e*) The development of a programme of research designed to meet the continuing problems of agriculture within the country.

4. That each nation should draw up periodic reports and submit them to the permanent organization.

It was further maintained that " the long-term policy must be developed out of the existing agricultural structure and within the general framework of consumption and also in accordance with the general cultural habits and traditions of the people concerned ", and full regard must be paid to " the physical and biological limitations imposed by soil, climate, and the adaptability of crops and animals to environment ".

The United Nations Interim Commission.—Upon the recommendation of the Hot Spring's Conference the United Nations Interim Commission, convened on the 15th July 1944, at Washington, consisted of one representative from each of the forty-four United Nations. Three major tasks lay before it : 1. To prepare the declaration whereby each government represented

accepted as an obligation to its own people and to all other governments the duty of improving nutrition and agriculture and to report progress. 2. To prepare specific plans for the permanent organization on food and agriculture called for by the Hot Spring's Conference; and 3. To carry out interim activities pending the creation of the permanent organization.

In August 1945 the Interim Commission issued its final report on "The Work of the Food and Agriculture Organization"; this is divided into Two Parts: I. Problems and II. Operations. In the First Part the problems are reviewed under the following headings: Freedom from Want; International Co-operation; Nutrition and Food Management; Agricultural Production; Fisheries; Marketing and Forestry and Primary Forest Products. In the Second Part, the following activities are discussed: Character of the work; Reports from member nations; International Missions; Committees and conferences; Relations with other organizations; Information, Library and other services; The first year (i.e. initial organisation).

To some, on first reading, some of these sub-titles may appear to cover spheres or subject matter not closely related to food and nutrition, but further consideration will reveal how inextricably inter-related all these activities are.

A General Survey of the Problems of the Food and Agriculture Organization (**F.A.O.**).—A crucial question which confronts the F.A.O. is; "Will such an organization be able to manage expanding production without running the risk of creating dangerous surpluses?" In the past, Governments, in solving the problems of surpluses acted solely in the best interests of their own people, and such action, in the absence of international co-operation, often resulted in the creation of further difficulties. Tariff barriers to keep foreign foods out, subsidies to push manufactured goods in to some other nation's home market; financial inducements to produce goods and commodities which could be made much more economically elsewhere; surpluses destroyed in the presence of crying human needs, these were some of the results of an unplanned economy. If the F.A.O. can bring an increased production of food and related products into correct relation to the needs of human individuals, or conversely, is instrumental in increasing purchasing power so that effective demand keeps pace with production, then the F.A.O. will have eradicated one of the greatest causes of world

malnutrition. The solution of the problem demands international collaboration, a more favourable and a more flexible balance between agriculture and industry, and the development of the less advanced countries, e.g. India, China, S.E. Europe, etc. This will require the compiling of data, factual and statistical, concerning the needs of populations, the consumption and production potential of many lands, and methods of transportation. Having regard to the great variety of foods and the many methods available for their production and preservation, the multiplicity of choice among the worlds many foods and the different food habits and social customs of the peoples of the earth, one can well imagine the extent of international co-operation that will be required if the nutritional needs of the peoples of the world are to be adequately met. The Conference at Hot Springs emphasized the lack of food production for energy needs. It has been stated that if the people of the United States are to have a diet which would furnish all the nutrient allowances as set out in the recommendation of the National Research Council (U.S.A.), the consumption of milk would have to be increased 50 to 60 per cent, fruits 50 per cent, eggs 15 per cent, meat 5 per cent and vegetables 100 to 120 per cent. This would mean that to feed adequately the whole population of the United States of America would result in the disappearance, for some time at least, of all food surpluses in America. That the United States would ultimately produce a surplus of certain foods goes without saying. Good nutrition, full employment and an adequate consumption of food cannot be dissociated the one from the other; they are essentially interrelated. Consider these three points in relation to present nutritional conditions in India, China and Africa. If the diets of the population of one of these three continents were to be brought up to the level of New Zealand or Australia, would the world be in a position to produce enough food to feed these people, or even to feed the livestock to supply the required amount of animal food? The answer is, NO. World malnutrition, briefly referred to in Chapter III, is so great that, without a well-organized body having the support of many sovereign states and specifically committed to the task, there can be no hope of grappling with the manifold problems which the situation presents. To grapple with these manifold problems is the aim and to do it with some measure of success is the hope of the F.A.O.

The Work of the F.A.O. in Agriculture.—To meet the nutritional needs of the world there is required a re-orientation of agriculture away from a too great production of staple cereal food and toward a greater output of live stock products, vegetables and fruits. Such a re-orientation must proceed along lines determined by two things ; first, a thorough knowledge of world production, actual and potential, and world requirements ; and second, the selection of countries or areas possessing natural and economic advantages. Market conditions, credit facilities and consumer purchasing power will need to be favourable to the welfare of farmers. " By the use of suitable economic adjustments and incentives, governments can do much to facilitate desirable re-orientation of production." The possibilities for increasing food production in many countries are enormous. Reference has been made to new methods in processing, dehydrating, preserving, quick freezing, transportation and storing of food. The lessons learned in methods of food distribution in this country during the war have been invaluable.

There is one important matter to which, because of its wide social implications, the F.A.O. will most surely give attention : the question of population in relation to agriculture. It is now general or common knowledge that agricultural development can never meet all the needs of those countries where there is an ever increasing growth of population. It becomes therefore, necessary to establish industries to absorb the increase of population. Rapid growth of populations without the means of adequate subsistence is a very critical problem in the East. If instead of labouring the value of British institutions in India, a great deal more practical attention had been paid to the problem of feeding the masses of India, there would probably, to-day, be less of discord, disease and death among the peoples of that great country. It is known that as industrial development advances the standards of living rise and because of inherent psychological adjustments, a fall in the birth rate occurs and, after a time, the population declines. The conclusion is inescapable that herein lies a factor which may be of value in solving " one of the most dangerous and potentially explosive problems of modern times ". Since ebb and flow are natural characteristics of all biological activity it will further become a duty of the F.A.O. to watch, guide and direct human endeavour into channels appropriate to the continued existence of a comparatively stable political life. To British people who know

India and have hopes that she will fulfil her political destiny in comparative quiet, the activities of the F.A.O. will be of particular interest.

In the field of agriculture elementary improvements will play a most important part. To help people to till the soil in a manner more in accord with the methods of the twentieth century A.D., than with those of the twentieth century B.C., will be a simple but essential task. Agricultural instruments, insecticides, and basic local industries supporting work on the soil will rapidly lead to better nourishment for man and beast and ultimately to the much needed development in the East of dairy farming and poultry breeding. In the East feudal types of landholding which prevent the development of the economic status of the farmer, tenure systems which permit the subdivision of large farms among the heirs from generation to generation and finally reduce the economic value of the land to a negligible figure, and the system of usury which entangles so many in its toils and destroys so much of potential wealth in the East, these are some of the matters which will not be settled in a day, but which will form a very important, if not an apparently major, part of F.A.O. duties.

Marketing.—In the less advanced countries one of the first essentials for food marketing is good roads. Waterways and railways must be developed and also modern methods of refrigeration for storage and transportation. If meat, fish, milk, eggs, vegetables and fruit are to reach the consumer in good condition they must be transported and stored under modern conditions. The processing and storage of food are of particular importance in the disposing of surpluses. International marketing and the related problems of tariffs and commodity arrangements will be matters for continual vigilance in order that the fruits of increased production may be properly directed into the expanding markets.

It may be surprising to some to know that this new Food and Agriculture Organization is not the first world organization set up to deal with agriculture. The only world organization of long standing is the International Institute of Agriculture in Rome, which for 40 years has been instrumental in the collection of data on numerous agricultural problems. Manifestly the F.A.O. is destined to play a much greater role in world affairs than has been the fortune of the Italian Institute, which it is thought will be merged into the F.A.O. Other bodies which

will doubtless become amalgamated with the F.A.O. are, the Centre International de Sylviculture (C.I.S.), the Comité International du Bois (C.I.B.) and the International Union of Forest Research Organizations. There are also several regional fishery organizations which will in time function as an integral part of the new and larger body.

Information, etc.—Since the F.A.O. will have to disseminate information it must have both a library and an information bureau ; a library to serve the needs of staff and all persons with field problems, to publish and make film and photostatic reproductions of important documents ; a bureau, where the results of scientific research, field investigations, statistical analyses, etc., can be made available to all.

Staffing.—The function of this new world organization, stated briefly, is to formulate the best means possible to advance the practical application of scientific knowledge of food and nutrition for the welfare of humanity. To this end the organization must have a staff of the highest scientific and professional ability, for the quality of the staff will determine the quality of the work that will be done. In the appointment of Sir John Boyd Orr, F.R.S., as its first Director-General, the Food and Agriculture World Organization has secured a man of vision, possessing a wide knowledge and experience in the field of world nutrition and the power of securing the best in work and loyalty from all who serve with him.

The problem of planning for World Food and Agriculture is one which not only immediately commends itself to all democratic authorities but affords the possibility, not only of ready agreement between nations, but of a large measure of success. To plan the production and distribution of food so that all nations should receive diets in conformity with the principles of satisfactory nutrition is to face boldly the major cause of world strife, namely, poverty, and to turn " the old contracting economy of security " into " the progressively expanding economy of abundance ".

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TABLE OF ENGLISH WEIGHTS AND MEASURES AND THEIR METRIC EQUIVALENTS

Ounce, fluid (British)	= 28·41 cubic centimetres.
Ounce, fluid (U.S.)	= 29·57 cubic centimetres.
Pint, Liquid (British)	= 20 fluid ounces (British)
	= 568·26 cubic centimetres
Pint, liquid (U.S.)	= 16 fluid ounces (U.S.)
	= 473·18 cubic centimetres
Gallon, (British Imperial)	= 10 pounds water (avoirdupois)
	= 8 pints, liquid (British)
	= 160 ounces fluid (British)
	= 277·3 cubic inches
	= 4·55 litres
Ounce (avoirdupois) (British)	= 1/16 or 0·0625 of a pound (avoirdupois)
	= 28·35 grams.
	= 437·5 grains.
Grain (gr.)	= 0·0648 gram.
Cubic Inch (in^3 or cu. in.) (British)	= 16·39 cubic centimetres
Inch (British)	= 2·54 centimetres
Foot (British)	= 30·48 centimetres
Pound (avoirdupois) (British) or U.S.)	= 27·69 cubic inches of water weighed in air at 4° C. and 760 mm. Hg. pressure
	= 16 ounces (avoirdupois)
	= 453·59 grams (avoirdupois)

TABLE OF METRIC WEIGHTS AND MEASURES AND THEIR ENGLISH EQUIVALENTS

Litres (1)	= 1·76 pints (British)
	= 2·11 pints (liquid) (U.S.)
	= 35·196 ounces (fluid, British)
	= 33·815 ounces (fluid, U.S.)
Millilitre (ml.)	= 0·035 ounce (fluid, British)
	= 1·000 cubic centimetre
Cubic centimetre ($cm.^3$, c.c.)	= 0·035 ounce (fluid, British)
	= 0·034 ounce (fluid, U.S.)
Kilogram (kg.)	= 1000 grams.
	= 2·205 pounds (avoirdupois)
	= 35·274 ounces (avoirdupois)
Gram (g.)	= 0·0022 pound (avoirdupois)
	= 0·035 ounce (avoirdupois)
	= 15·432 grains
Milligram (mg.)	= 0·001 gram.
Microgram (μg.)	= 0·001 milligram
Centimetre (cm.)	= 0·394 inch
	= 10·0 millimetres
Metre (m.)	= 100 centimetres
	= 39·37 inches (British)
	= 3·28 feet (British)
Kilometre (km.)	= 1000 metres.
	= 0·621 mile (statute)

PRESSURE

Atmosphere (normal)—Pressure exerted by 76 cm. of Hg. density 13·595 $g./cm.^3$	= 14·696 pounds per square inch
	= 29·921 inches mercury at 32° F.
	= 760·0 mm. mercury at 0° C.

ENERGY

Kilogram-calorie, or large calorie (Calorie)	= 1000 calories (i.e. small calories)
	= 3·97 (British) thermal units
	= 426·85 kilogram-metres

TEMPERATURE

Temperature degrees Centigrade (°C.) = 5/9 (°F. − 32)
Temperature degrees Fahrenheit (°F.) = 9/5 °C. + 32

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